INDIAN TEA ASSOCIATION

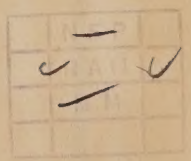
TOCKLAI EXPERIMENTAL STATION

MEMORANDUM No. 26

DISEASES OF TEA AND ASSOCIATED CROPS IN NORTH-EAST INDIA

by

K. C. Sarmah
Mycologist
Indian Tea Association
Scientific Department



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PREFACE

The major diseases of tea in North-east India have been described in the past in various I.T.A. Memoranda and also in the Tocklai Tea Encyclopaedia Serials, and revised control measures have been recommended from time to time in the latter as new data became available. However, there has been an increasing demand amongst many Tea Planters, especially the young assistants and trainees for such office, for non-technical descriptions of the important root, stem and leaf diseases of tea and its ancillary crops to be embodied in one single publication containing good, coloured illustrations. While the former does not present unsurmountable difficulties, the present day limitations in producing good, coloured plates in this country are many, more so when the finer details resulting from the effect of the diseases on different organs of the host plant are to be clearly reproduced without creating confusion with similar features of less importance.

This hand-book is intended to serve as a brief, practical guide to the planting community in North-east India in the identification of the commoner tea diseases and also in adopting suitable control measures according to the latest recommendations made by Tocklai. The disease symptoms have been recorded from the practical experience of the author and his predecessors, extending over a few decades. Attempts have been made to illustrate the difference in leading diagnostic symptoms between some important diseases and organisms of less importance (*viz.* (1) *Nectria* and *Aschersonia*, Red rust and *Stilbum nanum*) by means of coloured drawings. For detailed information on the control of important diseases the reader is referred to the Tocklai Encyclopaedia Serials which of course undergo revision from time to time in the light of new experience.

I am indebted to Mr. H. Ferguson, the Director, Mr. P. M. Glover, the Senior Advisory Officer, Assam, and Dr. V. Agnihothrudu, the Asst. Mycologist for critically reading the manuscript and for offering me their valuable suggestions. My thanks are due to Dr. Agnihothrudu also for preparing the index — a very laborious task, to Mr. P. C. Dowerah for the drawings, to Mr. E. P. Gee for coloured photographs and to the members of my staff from whom I received much help.

Tocklai,
1960.

K. C. Sarmah.

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Chapter One

INTRODUCTION

The tea bush like any other living plant is susceptible to attacks by diseases, more so as it has been forced to grow, under varying climatic and soil conditions remote from its natural environment. For the benefit of mankind it has also been subjected to various cultural treatments which are widely at variance with its natural conditions of growth.

The practice of tea cultivation, which necessitates the growing of a perennial, crop in a pure stand extending over a period of about 40 to 100 years and over a vast area affords a happy hunting ground for pests and diseases of all kinds.

Diseases of the tea bush and its ancillary crops may be caused by one or more of several agencies *viz*., (1) vegetable organisms, such as fungi, algae and bacteria, (2) animal parasites, (3) adverse conditions of soil and climate, (4) mechanical damage and (5) virus.

In the following pages the important diseases caused by the above agencies, except insect parasites, are dealt with in a more or less concise manner. Detailed data will be found in the publications listed at the end of each section.

DISEASES RELATED WITH VEGETABLE ORGANISMS

Vegetable organisms responsible for the disease of higher plants are (a) fungi (b) algae and (c) bacteria. Of these, the first two are known to cause diseases on tea, while the third (bacteria) is so far unknown to do so. Fungi alone account for all the recognised tea diseases caused by vegetable organisms except one, of which, the causal agent is an alga.

FUNGI

Fungi are living organisms of a very low order in the vegetable kingdom. Unlike higher plants, they are devoid of the green colouring matter—chlorophyll—principally concerned in photosynthesis. They do not have well differentiated organs such as roots, stems, leaves and flowers as in higher plants. Instead, their vegetative

portion, which is known as the mycelium, is comprised of extremely fine, microscopic, thread-like filaments (hyphae).

Higher plants, with the help of the chlorophyll and sun-light make use of carbon dioxide from the atmosphere, and chemical substances obtained from the soil through the roots to build up the plant material. Fungi being devoid of this important substance chlorophyll are incapable of manufacturing their own food. Their growth and existence must always depend on organic matter, either dead or alive.

Fungi are either parasitic—deriving their nourishment at the expense of living plants or animals or saprophytic—growing only on dead matter. There are, however, some facultative parasites which can live both as saprophytes and parasites. All these types are met with on the tea bush and they are here dealt with according to their influence on the health and growth of the plant. Saprophytes are not only harmless but in many cases beneficial. It is some of these saprophytic fungi and some soil bacteria that digest the dead organic matter and help in the process of converting dead woody materials, leaves etc., to humus which is so essential for improving soil fertility; in other words making better food substances available for their benefactors—the higher plants.

Diseases of tea have been divided into two groups *viz*. primary diseases which can cause death of healthy tissues or bushes even under the best of conditions, and secondary diseases which can be harmful if the health of the bushes is impaired by some other cause.

In tea and its associated crops those organisms which cause the primary as well as secondary diseases are facultative parasites. A few epiphytic fungi, growing superficially and thus not directly harmful to the tea bush, have also been included in the second group.

DISSEMINATION OF FUNGI AND MODE OF INFECTION

Fungi usually reproduce by means of tiny, microscopic structures known as spores, which function almost like seeds of higher plants. These spores are produced in thousands on a small spot about the size of a pin-head and a fungus in the course of a short period of its growth may produce millions of spores. Various forms of spores may be produced, by one species of fungus, in relation to climatic conditions and suitability of dissemination. The spores are mostly dispersed by wind, water and to some extent by insects, birds, cattle, workers (on their clothes), implements etc. They do not usually remain viable for long. Most of them die out within a short time of their liberation. Those happening to settle on the right sort of material in a suitable environment germinate and give rise to the fungus. Some fungi have been found not to produce spores on tea at all. Thread blight and *Rhizoctonia* are fungi of this nature. Such fungi are disseminated either by means of infected material carried from place to place by insects, birds, other animals, wind etc. or by direct contact.

There are still others which, in addition to the spores, produce resting bodies known as *sclerotia*. These are lumps of ramified mycelial structures often well protected from weather by a rind of protective tissues and varying in size from a pin point to a golf ball. Black rot and *Rhizoctonia bataticola* on tea are instances of such fungi. The *sclerotia* of some fungi, can remain viable for a number of years even when they are subjected to desiccation.

CAUSAL AGENTS OTHER THAN FUNGI

In addition to the fungal diseases, there are a few caused by other agencies. Some important instances are given below.

1. Red rust of tea is caused by an alga known as *Cephaleuros parasiticus* Karst. (page 44). This organism is a member of the same order of plants which form a green or brick-red scum on the surface of stagnant pools or change clear water to a green colour.

2. Yellowing and stunting of young nursery seedlings often followed by death may be caused by eelworms which severely damage the root system.

3. Rim blight or Marginal necrosis is a condition which may be produced by a number of factors as described on page 51.

4. Bark splitting followed by branch-canker may originate from sun-scorch; medium pruning is often followed by sun-scorch.

5. Sudden death of a large number of bushes in a group often results from lightning damage.

6. Girdling of the main stem by a ring of dead bark just at soil surface followed by wilting and death may occur due to faulty application of chemical manure.

7. Brown discolouration of the leaves and complete or partial defoliation of bushes may be effected by overdose of chemical manures. Sprinkling of chemical manure on the foliage also causes local burning.

8. Young plants may die out if decentering immediately follows or coincides with a period of vigorous shoot growth. Similar may be the case with mature bushes medium pruned at a time when their roots are devoid of reserves.

9. Wilting and death may be effected by drought.

10. Severe burning of leaves may be caused by sun-scorch, especially in poorly shaded areas, when the tea is exposed to hot, strong sun following a dull, wet period.

PRIMARY FUNGAL DISEASES OF TEA

The following are the important primary fungal diseases of tea occurring in N.E. India. Some are rare, others are fairly common.

Root diseases :

(a) Brown root rot—*Fomes lamaoensis* (Murr.) Sacc. and Trott.
=*Fomes noxius* Corner—Common.

(b) Charcoal stump rot—*Ustulina zonata* (Lev.) Sacc.
=*Ustulina deusta* (Fr.) Petrak—Very common.

(c) Red root rot—*Poria hypolateritia* (Berk.) Cooke—Not common.

(d) Black root rot—*Rosellinia arcuata* Petch— Common in the hills.

(e) Tarry root rot—*Hypoxylon asarcodes* (Theiss.) Mill. —Common in West Bengal.

(f) Purple root rot—*Helicobasidium compactum* Boedijn —Not common.

Stem diseases :

(a) *Nectria* Spp.—*Nectria cinnabarina*, (Tode ex Fr.) Fr. and *Nectria* sp.—Not common.

(b) *Poria hypobrunnea* Petch—Very common.

(c) Thread blight—Common.

(d) Pink disease—*Pellicularia salmonicolor* (B. & Br.) Rogers =*Corticium salmonicolor* B. & Br.—Rare.

Leaf diseases :

(a) Black rot—*Corticium invisum* Petch and *Corticium theae* Bernard —Very common.

(b) Blister blight—*Exobasidium vexans* Massee—Common in Darjeeling.

(c) *Botrytis* sp.—Rare.

SECONDARY DISEASES OF TEA

Amongst the secondary diseases the following are noteworthy.

Root diseases :

(a) Violet root rot—*Sphaerostilbe repens* B. & Br.—Common.

(b) *Diplodia* disease—*Botryodiplodia theobromae* Pat.—Common.

(c) *Rhizoctonia bataticola* (Taub.) Butler=*Macrophomina phaseoli* (Maubl.) Ashby—Common.

(d) Thorny blight—*Aglaospora* sp.—Not common.

(e) *Poria hypobrunnea* Petch—Very common.

(f) *Fomes lignosus* (Klotzsch) Bres.

(g) *Ganoderma lucidum* (Leys ex Fr.) Karst.

(h) *Ganoderma applanatum* (Pers. ex Wallr.) Pat. =*Fomes applanatus* Pers.

} Not Common.

Stem diseases :

(a) Thorny blight—*Aglaospora* sp.—Very common in West Bengal.

(b) *Macrophoma theicola* Petch=*Physalospora neglecta* Petch.
—Not common.

(c) *Diplodia* disease—*Botryodiplodia theobromae* Pat—Common.

(d) Jew's ear fungus—*Auricularia-auricula* (Hooke) Underwood
=*Auricularia auricula-judae* (Fr.) Schroet. — Not common.

(e) Velvet blights—(1) *Septobasidium bogoriense* Pat.
(2) *S. theae* Boed. and Stein.
(3) *S. tuberculatum* Boed. and Stein.
} Not common.

(f) *Aschersonia* sp.—common.

Leaf diseases :

(a) Brown blight—*Glomerella cingulata* (Stonem.) S & v. S.
=*Colletotrichum camelliae* Mass.—Very common.

(b) Grey blight—*Pestalozzia theae* Sawada—Very common.

(c) Sooty moulds—(1) *Capnodium* sp.
(2) *Limacinula theae* Syd. & Butl.
(3) *Meliola* sp.
} Not common.

Tea flower disease :

(a) *Botrytis* spp. (*Sclerotiniaceae*)—Common.

Some of the secondary diseases on stems and leaves are associated with insect attack and are superficial.

Chapter Two

ROOT DISEASES AND THEIR CONTROL

PRIMARY ROOT DISEASES

Nature of Infection

In healthy sections of tea, where there is no previous history of root diseases, initial infection takes place in most cases either by means of air-borne spores from some other source or by direct contact of roots with diseased woody material. The latter may be introduced into the area inadvertently through wooden fence posts, stepping blocks, bridging material, chips of fire-wood dropped while carrying etc.

Investigations carried out at Tocklai on the mode of infection of tea bushes have shown that some commoner root diseases are capable of infecting healthy and living wood when pure cultures on sterilised blocks of wood are placed in direct contact with the roots. In case of at least one primary root disease *viz.* Charcoal stump rot (*Ustulina zonata*) it has been found that bushes become severely infected when inoculated on damaged branches near the collar with spores of perithecial fructifications.

Black root rot (*Rosellinia arcuata*) is known to originate in dead matter lying on the ground (evidently from air-borne spores) and thence spread to healthy tea.

Hypoxylon asarcodes has been observed to establish itself in tea, initially through infection of damaged branches by means of air-borne spores.

How primary root diseases spread

(1) Once the diseases become established in the tea they spread by direct contact through the roots to their healthy neighbours.

(2) When uprooting diseased tea bushes or shade trees, if choppings of affected wood fly off or are thrown into the adjacent healthy tea, they can act as foci of infection.

(3) When uprooting diseased bushes some of the infected roots are left in soil, if roots of adjacent healthy bushes or young infills come into contact with this infected material they develop the disease.

Direct root contact is essential for the spread of primary root diseases. In addition, the fungi can remain viable on dead wood in the soil so long as the wood does not decay away completely.

PLATE 1

Brown root rot (*Fomes lamaoensis*). Note encrustation on the root, particularly at the collar, also brown reticulations in the piece of wood.

Root disease fungi may kill one to nine bushes (according to the spacing and planting arrangement) at a time in any one patch (see diagram on page 11) unless they spread from a diseased shade tree or more than one closely situated centre of infection when more deaths may be involved.

Brief descriptions of some of the more important root diseases of tea are given below.

BROWN ROOT ROT—*Fomes lamaœnsis* (Murr.) Sacc. and Trott.
=*Fomes noxius* Corner.

(Plate 1)

This disease is found on all soils but it is more common on sandy ones.

It usually occurs on tea plants from about 3 years upwards but younger plants may easily be attacked and killed in a few months if their roots happen to come in direct contact with diseased material in the soil. Diseased plants die suddenly and their leaves remain attached for sometime.

Roots of affected bushes are encrusted with soil, sand and stone particles held firmly by a brown mycelium, which sometimes forms sheets with a blackish surface. The crust is difficult to remove by washing or rubbing. Brown, soft mycelium grows on the main stem, often as a felt, extending to a few inches above the soil surface. A thin film of white to brownish mycelium may develop, on the surface of affected wood, underneath the bark. Colour of the wood is light yellow. Irregular rings or reticulations are formed by hard brown lines in the wood. In advanced cases the soft wood inside the brown rings decays, giving a honey-comb-like structure.

Fructifications of the fungus are extremely rare on tea. Infection spreads more through diseased woody material than through wind-borne spores.

In North-east India Brown root rot has been found to attack the following plants besides tea—*Albizzia odoratissima*, Koroi (*Albizzia procera*), Sau (*Albizzia chinensis*=*A. stipulata*), Bamboo, Arhar (*Cajanus indicus*), Jabaphul (*Hibiscus* sp.), Nahor (*Mesua ferrea*), Gold mohor (*Poinciana regia*), Simul (*Bombax malabaricum*), Sal (*Shorea robusta*), Dadap (*Erythrina* spp.), Sonaru (*Cassia fistula*), Ghoraneem (*Melia azedarach*), Khair (*Acacia catechu*), Sissoo (*Dalbergia sissoo*), *Derris robusta* and *Semicarpus anacardium*.

CHARCOAL STUMP ROT—*Ustulina zonata* (Lev.) Sacc.
=*Ustulina deusta* (Fr.) Petrak

(Plate 2)

Charcoal Stump rot occurs on all soils. It is found in all the tea growing areas and is probably the commonest of all the primary root diseases of tea in North-east India.

It attacks all tea from about 3 years upwards. Diseased bushes, especially the young ones, die suddenly and the withered leaves remain attached for sometime. Sometimes older bushes may be dead and rotten on one side while the other side remains apparently healthy for a long time.

The fungus develops a characteristic fructification, at first white changing to charcoal-like, black, brittle encrustation, which is wavy on the surface. It appears on the bark and exposed wood at the collar region or on exposed roots. The root surface usually bears small, white or black, isolated, cushions or lumps. Fan-like felts of dull-white, silky mycelium grow on the surface of diseased wood, underneath the bark. Colour of the wood is dull-white, almost normal. It is permeated by irregular, single or double, black bands or lines.

The fungus spreads (1) by contact through the roots (2) through diseased woody material and (3) through wind-borne spores.

Charcoal stump rot attacks many other plants besides tea. The following hosts have been recorded :—*Aleurites montana*, *Albizzia chinensis* (=*A. stipulata*), *Albizzia falcata* (=*A. moluccana*), *Albizzia odoratissima*, *Albizzia procera*, *Derris robusta*, *Shorea robusta*, *Cassia nodosa*, *Lafoensia vandelliana*, *Citrus decumana* (Pomelo), *Tephrosia candida* and *Cajanus indicus*.

RED ROOT ROT—*Poria hypolateritia* (Berk.) Cooke

(Plate 3)

Red root rot is found on all soils but it is less common than Brown root rot and Charcoal stump rot. The disease is more prevalent in the Surma Valley than in other tea growing areas. It attacks all tea from about 3 years upwards. Diseased plants die suddenly and their withered leaves remain attached for sometime.

In the early stages of attack, the roots of tea bushes, especially of the young ones, bear white threads or cords of mycelium on the surface. Later on these cords change colour, fuse with one another or spread out at intervals to form chocolate-red to black sheets. The cords and sheets are white underneath. Roots are usually encrusted with soil, sand and stone particles held by these white and chocolate-red to black cords or sheets of mycelium, the whole thing presenting a mottled appearance of white, red and black. A thin film of white mycelium may develop on the surface of diseased wood underneath the bark. Colour of wood is normal except in very advanced cases when it becomes soft and sodden.

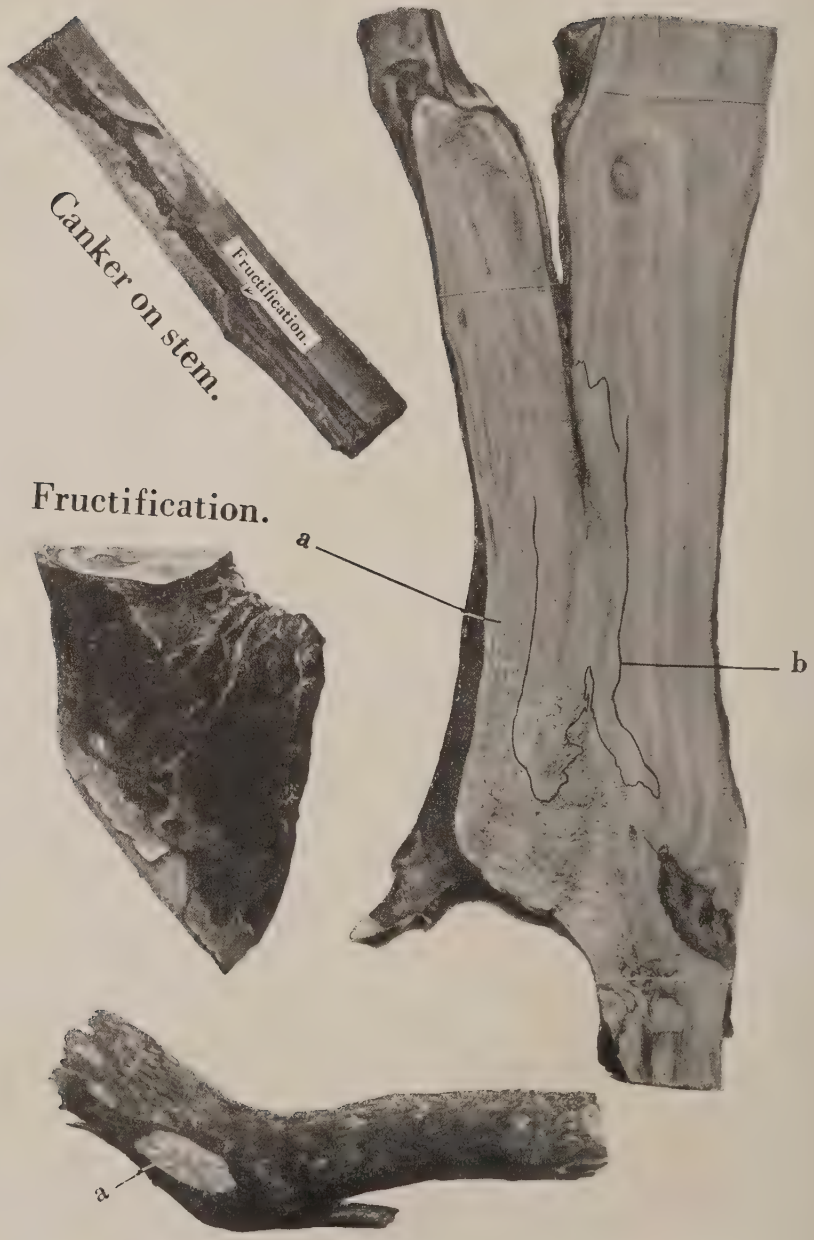
Fructifications of the fungus are extremely rare and so infection spreads mostly by direct contact with diseased material.

In North-east India it has so far been recorded mostly on tea. Other hosts are *Ficus* spp. (Bor and Peepal), *Tephrosia vogelii* and *Crotalaria*.

Charcoal stump rot (*Ustulina zonata*). Note black crust of fructifications at the top, tan-like film of mycelium in the middle and black lines in the wood at the bottom of the picture

Red root rot (*Poria hypolateritia*). Note encrustation on the root surface on the left and white threads and films of fungus on a young tea root on the right.

Black root rot (*Rosellinia arcuata*) (a) Black, shot-like fructifications, (b) black strands of mycelium on the surface of root and (c) white and black star-like markings on the surface of the wood.



Tarry root rot (*Hypoxylon asarcodes*) (a) brown reticulations and (b) black lines in the wood. Note also smooth, black fructifications and canker on the stem.

BLACK ROOT ROT—*Rosellinia arcuata* Petch

(Plate 4)

This disease is found in all tea districts but it is more common in the hills than in the plains. It attacks young as well as mature tea plants but it has been recorded mostly on the latter. Diseased bushes die suddenly and the withered leaves remain attached for sometime.

The fungus forms, black, irregular, cob-webby, adherent cords of mycelium and small, isolated black dots and dashes, on the root surface. Woolly, purplish-grey to black stocking of mycelium may be produced on the stem to a few inches above the soil surface. Small, white to black, star-like markings accompanied by numerous small black dots and dashes develop on the surface of the wood, underneath the bark. The wood of the root is permeated by the latter (dots and dashes).

Two types of fructifications are produced on the stem at or a little above the collar. One type (the conidial stage) is not discernible to the naked eye. The second (perithecial stage) consists of black, spherical bodies, which look like grains of shot, growing side by side to form a crust.

Infection spreads either through wind-borne spores or direct contact with diseased material or mycelial cords which are known to grow freely in the soil containing a lot of dead vegetable matter.

The disease has also been found to attack *Albizzia procera*, *Cajanus indicus*, *Erythrina* sp., *Grevillea robusta*, *Indigofera dosua*, *Mangifera indica* and *Symplocos* sp.

TARRY ROOT ROT—*Hypoxylon asarcodes* (Theiss.) Mill.

(Plate 5)

This disease has been found to occur in the tea growing areas of West Bengal. Probably it is more prevalent in soils consisting of sand and gravel. It has been recorded on tea in Assam only in one case.

In all instances the disease has been found to occur on mature tea bushes only. Affected bushes die suddenly and the withered leaves remain attached for sometime.

The fungus does not produce any external symptoms on the affected roots. The stem, from the ground level upwards to several inches, develops a black encrustation which is smooth, hard, effused and adherent, similar in appearance to dried wound paint. On rare occasions it produces on the stems abnormal callus growth similar in appearance to that caused by *Macrophoma theicola*. The wood of the root forms thin, dark-black lines similar to those of *Ustulina zonata* and small, brownish reticulations.

Infection spreads through wind-borne spores and direct contact with diseased material.

Besides tea the fungus has been recorded only on *Albizzia procera* (Koroi).

PURPLE ROOT ROT—*Helicobasidium compactum* Boedijn

(Plate 6)

This disease is found on all soils. It usually attacks young tea of about 1-8 years but it can kill bushes as old as 50 years. The disease, however, is not common.

Diseased roots usually develop on their surface numerous, round, purplish pustules about the size of a pin-head and also purple-brown, branched mycelial cords or strands which run along the surface upto the collar region. A thick, velvety mycelial pad, purplish-brown, sometimes resembling the colour of stale chocolate, is produced just above the soil level often surrounding the whole stem to several inches. Colour of the affected wood is pinkish.

Affected plants die suddenly and their withered leaves remain attached for sometime.

Spores of the fungus are produced on the velvety pad at the collar. Infection spreads through contact with diseased material as well as wind-borne spores.

In North-east India hosts of the fungus other than tea so far recorded are *Tephrosia candida*, *Albizzia chinensis* (=*A. stipulata*) and *Albizzia procera*.

CONTROL MEASURES FOR PRIMARY ROOT DISEASES.

There is no known method of detecting the presence of most of the root diseases in the roots of the tea bush until either the whole bush or part thereof dies suddenly. A bush infected through the lateral roots on one side may present a normal appearance for several years, although the infected roots may be dead, because the supply of sap and soil water is carried on by the rest of the root system. Gradually the fungus concerned extends along the roots to the collar region killing the host tissues as it proceeds. This process may take about $\frac{1}{2}$—4 years according to the age and the size of the plant. Sometimes healthy bushes surrounding a dead bush or a vacancy caused by certain primary root diseases may show a dead branch or two on the side adjoining the focal centre sometime before their death and they may also show some symptoms of the disease at the collar but these indications are often missed. By the time such symptoms become noticeable or the bush is killed, some of its adjacent neighbours will in all probability have also been infected by contact through the roots.

It is therefore, absolutely essential in digging up bushes affected by a primary root disease to uproot a complete ring of apparently healthy surrounds at the same time.

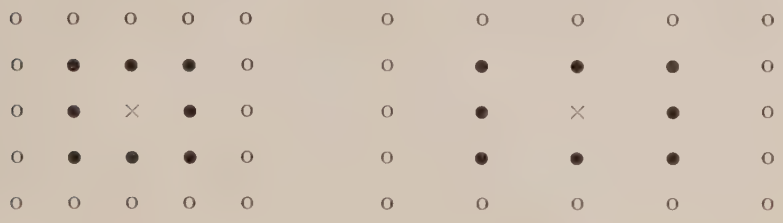
The following diagram illustrates the position of the diseased bush and the number of healthy bushes involved in the ring according to different spacing arrangements.

A B

Purple root rot (*Helicobasidium compactum*). Note soft, purplish pads of mycelium at the collar on (A) and (B) also purplish strand on the root surface on (B).

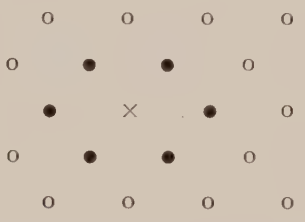
DIAGRAM No. 1.

UPROOTING TREATMENT IN CONTROL OF PRIMARY ROOT ROTS IN TEA AT VARYING SPACINGS



SQUARE PLANTED 4′×4′
=1.2×1.2 metres.
(9 Bushes—64 sq. ft.
=5.94 sq. metres)

HEDGE PLANTED 5′×2′
=1.52×0.6 metres.
(9 Bushes—40 sq. ft.
=3.71 sq. metres)



TRIANGULAR PLANTED $4\frac{1}{4}'\times4\frac{1}{4}'$=1.29×1.29 metres.
(7 bushes – 56.5 sq. ft. =5.24 sq. metres)

In each instance the diseased bush is shown ×, and those in immediate contact with it, which must be uprooted to check the spread of the disease, are shown thus ●. Healthy bushes which may remain are shown o.

It will be noted that in square planted tea 9 bushes must be uprooted including the diseased one. At 4′×4′ (1.2×1.2 metres) square the area involved is 64 sq. ft. (5.94 sq. metres).

In triangular planted tea 7 bushes must be removed including that diseased, and at $4\frac{1}{4}'\times4\frac{1}{4}'$ (1.29×1.29 metres) the area involved is 56.5 sq. ft. (5.24 sq. metres).

In hedge planted tea 9 bushes must be uprooted including the diseased one, and at 5′×2′ (1.52×0.6 metres), the area involved is 40 sq. ft. (3.71 sq. metres).

All dead woody material encountered during the uprooting operation should be completely removed from the soil. The area should then be put under a green crop such as Boga medeloa (*Tephrosia candida*) or *Crotalaria anagyroides* for at least a year, preferably 2 years before replanting. This time interval will allow the smaller woody material in the soil, that may have been missed at the time of uprooting, to decay away.

In no case should a vacancy caused by a primary root disease be infilled immediately.

Where the incidence of these diseases is very high and widespread, it is often extremely difficult to undertake control measures on a large enough scale to deal with the whole estate at one time. It is recommended that such work be done to the maximum possible extent according to the following priorities :

1. When disease occurs on individual bushes in otherwise healthy areas, complete eradication of diseased bush and its surrounds.

2. Where disease occurs in small patches, mark out and remove all bushes therein with their roots ensuring that the area cleared of infected bushes includes at least one ring of apparently healthy ones.

3. Where a large area is concerned and immediate attention is not possible it should be isolated by a trench at least 3′ (0.91 metre) deep and 1′ (0.3 metre) wide until the digging up can be undertaken. The trench must be kept clean and open. Where trenching is not possible isolate the area by uprooting 2 rows of healthy tea at the edge.

4. Where old tea, due for replanting, in the near future, is attacked by root rots segregate the area as described in para (3). Remove only the obviously diseased or dead bushes. Pluck the rest for what they are worth. Dig up all bushes 2 years ahead of replanting removing all woody material from the soil. Put the area under a green crop for 2 years and then replant.

When uprooting bushes the use of a sub-soiler will help a lot in bringing buried bits of root to the surface. Uprooting by tractor is far more efficient than by hoe as more roots are removed by the former process.

There is a double purpose of putting an uprooted area under green crop. Firstly it helps to a great extent in rehabilitating the soil which had carried tea over a few decades. Secondly it serves as a test crop. In the latter case if any plant gets affected by a primary root disease it should be carefully dug up together with 2 or 3 rings of healthy plants. The soil should be thoroughly searched, to a depth to which the roots of the green crop have grown, for the presence of any diseased woody material.

Shade trees killed by primary root diseases should be romoved carefully tracing out the roots as far as possible. In thinning out healthy shade trees, it is advisable to ring-bark them sometime prior to the production of new leaf. This in most cases will cause them to die due to exhaustion of reserves. They should then be cut down. Where it is not possible to remove the stumps, they should be cut sufficiently low for the stumps to be covered up by about a foot (0.3 metre) of soil. If this be done immediately after cutting, the danger of the stumps becoming infected by wind-borne spores through the cut surface is considerably reduced, especially in soft-wooded varieties. Stumps of hard-wooded trees such as Nahor (*Mesua ferrea*), Sal (*Shorea robusta*), Khair (*Acacia catechu*) and *Derris robusta* take a long time to decay and are likely to act as centres of infection to the tea later. Roots of such trees should be carefully dug out.

These treatments may appear to be drastic but a primary root disease is a serious thing and if control measures are not taken up properly it may cause a loss of thousands of bushes later on.

Where gardens have followed Tocklai's advice methodically they have been able to control and finally to eradicate primary root diseases before they have reached an epidemic stage. Where a policy of removing only the dead bush is followed the affected area increases with remarkable rapidity until any form of control becomes virtually impossible and in one particular instance a garden which adopted incorrect method in the past is now losing 20 to 30 thousand bushes, representing between 7 and 10 acres (2·83 and 4·04 hectares) of tea, per annum.

Always make it a point not to leave dead shade trees or tea bushes in the soil for long even if the cause of death is other than a primary root disease.

Bushes killed by lightning should be removed as soon as possible as they are likely to be rapidly attacked by Charcoal stump rot (see page 54).

SECONDARY ROOT DISEASES

Almost all the fungi causing secondary root diseases of tea are very common, either in the soil or above ground. Their damage to the tea bush is either associated with adverse soil conditions or impaired health and vigour due to other causes. There must be factors or a combination of factors which make the tea bush susceptible to attacks by such fungi. These predisposing factors may not be the same in each case. For instance the conditions favouring the attack of Violet root rot need not necessarily be present in case of Thorny blight or *Diplodia* disease. Unlike most primary root diseases secondary ones in many cases may be avoided by correcting the causes in good time.

In dealing with a bush killed by any of the secondary root diseases only the dead bush should be removed; it is NOT NECESSARY OR ADVISABLE to uproot a ring of healthy surrounds as in case of primary root diseases.

Brief descriptions of the commoner secondary root diseases and their control measures are given below.

VIOLET ROOT ROT—*Sphaerostilbe repens* B. & Br.

(Plate 7)

Violet root rot is found on all soils but it is more common on stiff, clayey ones. The disease is practically unknown in the hills. It attacks all tea from about 1 year upwards but the characteristic symptoms are produced on plants of about 2 years and above. Diseased plants die gradually, leaves turn yellowish, droop and become flaccid and often drop off while still green. The disease always follows poor soil aeration or waterlogging of the soil.

Surface of the roots, growing in poorly aerated soils, is roughened due to enlargement of lenticels and then affected by Violet root rot. Roots are either inky black or light violet in colour and freshly dug up ones often smell sour and vinegary.

When the bark of affected roots is peeled off the wood surface is found to be covered with thick, irregular, white to orange and then mauve to purplish-black, flattened strands (rhizomorphs). Fructifications of the fungus are of two kinds; (1) diseased roots when exposed to weather for a few days develop on the surface small groups of pinkish or orange coloured pins about $\frac{1}{8}$" (3·17 m.m.) long with white heads, (the conidial tufts)—these shrivel and dry up in a few days leaving no trace: (2) the second type is produced on the stem, at or a little above the collar, and on exposed roots, as clusters of minute, red to black, flower-bud-like bodies (perithecia).

The fungus is a very common soil dweller.

It has been recorded in North-east India on the following plants besides tea.

Albizzia chinensis (*A. stipulata*), *Albizzia falcata* (*A. moluccana*), *Albizzia odoratissima*, *Albizzia procera*, *Artocarpus integrifolia*, *Crotalaria grahamiana*, *Derris robusta*, *Erythrina* sp., *Gliricidia sepium* (*G. maculata*), *Priotropis cytisoides* and *Tephrosia candida*.

Predisposing causes of Violet root rot

Violet root rot only attacks plants which are subjected to waterlogging or bad aeration of the soil. These conditions are mainly due to flood, low lie of the land with a high water table, faulty drainage, back feeding or collapsing of drains during the rains, spreading of a thick layer of clayey subsoil around the collar of drain-side bushes while deepening drains etc. Waterlogging may also be induced either by cheeling away soil from around the collars leaving the bushes in small depressions which hold rain water for longer periods than is good for their health or by puddling the soil while cheeling in the rains in wet periods.

Control measures

Improve aeration of the soil by proper drainage and maintain drains in working order.

Improve physical condition of the soil where necessary, by green manuring, green cropping and by growing deep rooting species of shade.

Do not cheel away soil from under the bushes without replacing it.

When deepening drains, do not pile subsoil thickly round the collars of bushes.

Try to establish good shade by using species tolerant of wet soil conditions.

Do not apply chemical manures in low lying areas in wet weather.

DIPLODIA DISEASE—*Botryodiplodia theobromae* Pat.

This disease occurs on all soils but it is more common on sandy ones. It is probably the commonest of all the fungi recorded on tea in North-east India. It can attack any part of the tea plant, young or old, only when the plant is debilitated by other causes.

A B

Violet root rot (*Sphaerostilbe repens*). Note enlarged lenticels on the root bark in (A) and purplish-black strands on the surface of wood in (B).

A

B

Thorny blight (*Aglaospora* sp.)
(A) Thorny fructifications and black lines on tea stems.

When it occurs as a root disease it does not produce any external mycelium or any other characteristic symptom by which it can be easily recognised. Affected roots usually look normal except in very advanced cases where the surface is covered with small, isolated or groups of greyish-black to coal-black, hairy cushions, giving a sooty appearance. These are sometimes produced also at the collar region. The wood when sliced often shows an even, bluish-black discolouration.

Infection is believed to take place through airborne spores.

Diplodia is found on dead or dying roots and twigs of practically all woody plants.

Control measures

Lack of reserves, in other words, general debility, is the main predisposing cause of attack. It is, therefore, necessary to improve the general health and vigour of the plants by judicious cultural and manurial treatments.

RHIZOCTONIA BATATICOLA (Taub.) Butler
=*Macrophomina phaseoli* (Maubl.) Ashby

Found on all soils but more common on sandy ones. It attacks all teas, young and old, when they are debilitated by other causes as does *Diplodia*. Very often the two diseases occur together since their attack is favoured by the same conditions.

Affected roots do not develop any outward symptoms. Minute, irregular black dots (*sclerotia*) are produced in numbers on the surface of the wood beneath the bark and also in the wood. Roots attacked by *Rhizoctonia* are very light and completely devoid of reserves.

Control measures

Same treatment as for *Diplodia* is applicable to this disease.

THORNY BLIGHT—*Aglaospora* sp.
(Plate 8)

This is more a disease of the stems than of the roots of tea. It enters the bush through the stems and gradually extends down into the roots when the bush is compppletely killed (see under Stem diseases, page 28).

On the roots it does not produce any external mycelium. Fructifications of the fungus appear on the roots as small, round swellings on the bark, about 1—1·5 m.m. accross with a pointed, black, thorn-like projection about 1—1·5 m.m. long in the centre. They occur singly or in groups. Black, fern-leaf-like fans of mycelium form on the wood surface beneath the bark. The wood is discoloured with inky-black patches. Black lines appear in the wood.

Infection takes place by spores and not by direct contact through the roots.

The disease has also been recorded on the roots of *Albizzia falcata* (*A. moluccana*).

Control measures

It is a secondary disease of weak bushes. Dead bushes should be uprooted and the vacancies infilled as soon as convenient. For preventive measures see page 28.

PORIA HYPOBRUNNEA Petch.

It is a stem-cum-root disease of tea. It always gains its entrance through wounds on the branches and slowly extends down to the roots when the affected bushes are completely killed (see under Stem diseases, page 25).

The disease is extremely common on mature tea throughout the whole of North-east India. Affected bushes die gradually.

Thin films and small cushions of yellowish-brown mycelium are produced on the root surface as well as on the wood, beneath the bark. Wood is yellowish, soft and decayed, marked with thin, irregular, light-brown lines and permeated with thin sheets of yellowish-brown mycelium. Because of these symptoms it is often confused with Brown root rot. There are, however, some important distinguishing features.

(1) In *Poria hypobrunnea* the affected bush rots and decays from above the ground downwards whereas the effect is just the reverse in Brown root rot.

(2) Brown root rot binds the soil, sand and stone particles into a crust on the root surface whereas *Poria hypobrunnea* does not.

(3) The brown lines or reticulations in the wood are usually darker in colour in Brown root rot than those in *Poria hypobrunnea*.

The fungus does not spread by contact through diseased roots.

Control

The dead bushes should only be removed; it is not necessary to uproot a ring of healthy bushes surrounding the diseased one. Vacancies may be infilled as soon as convenient.

(For preventive measures see Branch canker, pages 25-26).

GANODERMA LUCIDUM (Leys ex Fr.) Karst.=(*Fomes lucidus*).

It is found on all soils. It occurs on tea of all ages but only as a secondary infection. The fungus is not a common disease of tea. Affected bushes die part by part.

Diseased roots are usually covered with thick, tough, white cords or bands. The wood becomes darker in colour and contains cavities filled with white mycelium and/or scattered patches of white mycelium. Fructifications of the fungus are produced, at the collar, as thick brackets with the upper surface smooth, yellowish to deep red, shining as if lacquered, concentrically zoned with the margin and the under surface white in colour. The size varies from 2 inches (5·0 cm.) to over a foot (30 cm.) in diameter and from about $\frac{1}{2}$—4 inches (1·2 cm. to 10·1 cm.) in thickness on tea and jungle trees respectively.

Infection takes place through wounds above ground by means of air-borne spores. It does not spread to healthy tea by contact.

The fungus has been noticed on stumps of many trees including the shade species.

Control

Removal of the dead bush is all that is necessary. Infill the vacancy as soon as convenient.

GANODERMA APPLANATUM (Pers. ex Wallr.) Pat.
=*Fomes applanatus* (Pers) Wallr., and
FOMES LIGNOSUS Klotzsch.

These bracket fungi attack the roots of tea bushes when most of the above-ground portion is severely damaged or killed by other agencies. None of them has been found to attack healthy tea.

These diseases do not spread by contact through the roots. Removal of only the dead bush is all that is necessary. The vacancy may be infilled as soon as convenient.

KEYS FOR IDENTIFICATION OF THE COMMONER ROOT DISEASES OF TEA

The following five keys will be found helpful in identifying the commoner root diseases of tea.

I. KEY TO EXTERNAL APPEARANCE OF BUSHES IN THE FIELD.

II. KEY TO INDICATIONS ON THE COLLAR REGION.

III. KEY TO EXTERNAL APPEARANCE OF THE SURFACE OF THE ROOTS WHEN THE BUSH IS DUG OUT.

IV. KEY TO INDICATIONS WHEN THE BARK IS PEELED AWAY FROM THE ROOT.

V. KEY TO INDICATIONS WHEN A CUT IS MADE INTO THE ROOT WITH A KNIFE.

It will rarely be possible to obtain an identification with one key alone, the joint use of the five keys should, however, make identification of all but the rarer root diseases fairly simple.

I. KEY TO EXTERNAL APPEARANCE OF BUSHES IN THE FIELD.

A. **Whole bushes die suddenly : withered leaves remain attached.**

1. Individual bush or rarely a small group of not more than 9 bushes dies, leaves green to reddish in colour, withered leaves remain attached :

   Brown root rot (*Fomes lamaoensis*).

   Red root rot (*Poria hypolateritia*).

   Black root rot (*Rosellinia arcuata*).

   Tarry root rot (*Hypoxylon asarcodes*).

   Purple root rot (*Helicobasidium compactum*).

   Charcoal stump rot (*Ustulina zonata*).

   Young plants attacked through the tap root.

2. Groups of bushes, usually 10 or more die, sometimes beneath a living shade tree. Leaves bright reddish brown, attached. Withered leaves may have a gummy film on the under surface : Lightning.

B. **Part of bush only dies suddenly.**

Mature bush with part dead and remainder apparently normal and healthy. Dead part may be completely rotten :

Charcoal stump rot (*Ustulina zonata*).

C. **Bush does not die suddenly.**

Leaves turn yellowish, droop and become flaccid, often drop off while still green :

Violet root rot (*Sphaerostilbe repens*).

II. KEY TO INDICATIONS ON THE COLLAR REGION

A. **Collar with encrustation.**

1. Encrustation at first white, then greenish-grey, finally black. Surface undulated brittle, charcoal-like when broken :

   Charcoal stump rot (*Ustulina zonata*).

2. Encrustation black, effused, hard, surface of crust smooth and even, like dried black paint : Tarry root rot (*Hypoxylon asarcodes*).

3. Encrustation yellowish to fawn coloured changing to dull grey, effused, corky, may be on the collar, but more usually on the undersides of big branches :

Poria hypobrunnea.

B. **Collar without encrustation, but with mycelial growth.**

1. Thick pad of velvety, purplish-brown mycelium surrounding the collar :

Purple root rot (*Helicobasidium compactum*).

2. Woolly, greyish stocking of mycelium sometimes extending to base of the branches:

Black root rot (*Rosellinia arcuata*).

3. Brown, soft mycelium extending up the main stem to several inches :

Brown root rot (*Fomes lamaoensis*).

C. **Collar with pronounced bracket-like growths.**

1. Brackets brown, soft, gelatinous, resembling human ears :

Jew's ear fungus (*Auricularia auricula*).

2. Brackets thick, hard, dull, uppersurface marked with grey and brown concentric zonations, undersurface dull white :

Fomes applanatus (=*Ganoderma applanatum*).

3. Brackets semi-circular, thick, woody, smooth with a yellow brown margin, red-brown, with concentric dark brown lines, concentrically grooved or furrowed, radially striated, silky, lowersurface deep orange, changing to red, brown with age, sometimes several occurring one above another :

Fomes lignosus.

4. Brackets sometimes stalked, thick, uppersurface smooth, yellowish red to deep red, shining, lacquered, concentrically zoned. Immature ones are swollen and white at the edges, undersurface white :

Fomes lucidus (=*Ganoderma lucidum*).

5. Thin, red-brown, vertical plates adhering to the surface, with thin, horizontal brackets at the upper end, sometimes several occurring one above the other, undersurface of horizontal plates bearing tooth-like projections, vertical plates marked with furrows : *Irpex destruens.*

D. **Collar with small shot-like or flask-like bodies, or small thorn-like projections.**

1. Small, black, thorn-like, pointed projections, singly or in groups :

Thorny blight (*Aglaospora* sp.)

2. Small, black, spherical bodies like grains of shot, growing side by side on main stem or at the base of big branches :

Black root rot (*Rosellinia arcuata*).

3. Very small, red to black, flask-shaped bodies either at the collar or at the base of big branches, in clusters which look like tiny flower buds :

Violet root rot (*Sphaerostilbe repens*).

E. **Collar with cushion-like bodies.**

Collar with small, greyish black to black cushions, occasionally hairy, giving a soot-like appearance : *Diplodia* sp.

III. KEY TO EXTERNAL APPEARANCE OF SURFACE OF ROOTS WHEN BUSH IS DUG OUT

A. **Roots with an encrustation of soil, sand, stone particles etc.**

1. Mycelium cream to brown, general colour of root mottled brown, and black :

Brown root rot (*Fomes lamaoensis*).

2. Mycelium white to chocolate red or black cords or sheets (white on the inside) general colour of root mottled with red, black and white :

Red root rot (*Poria hypolateritia*).

B. **Roots without an encrustation of soil, sand or stone particles.**

B. 1. Root without cords or strands of mycelium on the surface.

1. Root with cushions or lumps.

(a) White or black cushions or lumps :

Charcoal stump rot (*Ustulina zonata*).

(b) Small greyish-black to black cushions or lumps, sometimes hairy, giving a sooty appearance : *Diplodia* sp.

(c) Small yellowish-brown cushions or lumps :

Poria hypobrunnea.

2. Root without cushions or lumps.

(a) Root violet in colour, sometimes inky-black, with a sour smell like vinegar. Lenticels often enlarged (*i.e.* surface rough with brown, corky, longitudinal depressions with slightly raised edges). Groups of small, orange-red pins with white heads (almost like fructifications of *Stilbum nanum*) on the root surface. Associated with waterlogging or poorly aerated soils :

Violet root rot (*Sphaerostilbe repens*).

(b) Root with black, pointed thorns, bark raised at base of thorns :

Thorny blight (*Aglaospora* sp.)

B. 2. Root with cords or strands of mycelium on the surface.

1. Cords of mycelium purplish brown, cords branched, giving root a general purplish brown colour : Purple root rot (*Helicobasidium compactum*).

2. Cords or bands tough, thick, white :

Fomes lucidus (=*Ganoderma lucidum*).

3. Cords or strands tough, white to yellowish or reddish, flat, forming a net work :

Fomes lignosus.

4. Cords thick, black, root with mushroom-like smell :

Armillaria mellea.

5. Cords cobwebby, black or greyish black, loose or adherent :

Black root rot (*Rosellinia arcuata*, *Rosellinia* sp.)

IV. KEY TO INDICATIONS WHEN THE BARK IS PEELED AWAY FROM THE ROOT

A. **Strands of mycelium on the wood surface.**

1. Strands irregular, thick, flat, white to orange, then mauve to purplish black :

Violet root rot (*Sphaerostilbe repens*).

2. Strands small, star-like, white to black, usually accompanied by small irregular dots and dashes : Black root rot (*Rosellinia arcuata*).

3. Strands black, fern-like : Thorny blight (*Aglaospora* sp.)

B. **Film of mycelium on wood surface.**

1. Film thin white : Red root rot (*Poria hypolateritia*).

2. Film dull white, silky, and fan-like :

Charcoal stump rot (*Ustulina zonata*).

3. Film very thick, white, with mushroom-like smell :

Armillaria mellea.

4. Film yellowish-brown : *Poria hypobrunnea*.

5. Film a thin layer of white or brownish mycelium :

Brown root rot (*Fomes lamaoensis*).

6. Film scattered patches of brownish-white mycelium :

Fomes applanatus (=*Ganoderma applanatum*).

C. **Without film or strands, with dots or dashes on wood surface.**

1. Minute black dots, close together in severe cases :

Rhizoctonia bataticola.

2. Small irregular dots and dashes usually mixed with starlike strands :

Black root rot (*Rosellinia arcuata*).

V. KEY TO INDICATIONS WHEN A CUT IS MADE INTO THE ROOT WITH A KNIFE

A. **Wood with dark bands or reticulations.**

A. 1. With dark black bands only.

1. Wood normal : Charcoal stump rot (*Ustulina zonata*).

2. Wood evenly black : Thorny blight (*Aglaospora* sp.)

A. 2. With dark black bands and reticulations.

1. Wood with dark bands and small reticulations of light brown, thin lines :

Tarry root rot (*Hypoxylon asarcodes*).

A. 3. With reticulations only.

1. Reticulations of thin, irregular, yellowish-brown lines, colour of wood light yellow : *Poria hypobrunnea.*

2. Reticulations of hard brown lines, irregular with cream coloured, soft wood between them, giving a honey-comb-structure in advanced cases. Colour of wood light yellow : Brown root rot (*Fomes lamaoensis*).

B. **Wood without bands, reticulations or mycelium.**

1. Colour dark brown, even : Lightning.

2. Colour pink to pinkish-brown: Purple root rot (*Helicobasidium compactum*).

3. Colour blue-black : *Diplodia* sp.

4. Colour mauve or purplish or inky-black :

Violet root rot (*Sphaerostilbe repens*).

C. **Wood with dots and/or dashes.**

1. Wood with numerous minute black dots :

Rhizoctonia bataticola.

2. Wood with black dots and dashes :

Black root rot (*Rosellinia arcuata*).

D. **Wood with sheets of mycelium.**

1. Mycelium yellowish-brown : *Poria hypobrunnea.*

2. Wood with cavities filled with white mycelium or with small, scattered patches of white mycelium : *Fomes applanatus=Ganoderma applanatum.*
Fomes lucidus=Ganoderma lucidum.

3. Wood with longitudinal cracks filled with mycelium :

Armillaria mellea.

References.

I.T.A. Memorandum No. 8—Notes on Root diseases of Tea in North-east India by A.C. Tunstall (1940).

The diseases of the Tea bush by T. Petch (1923).

Tea Pests and Diseases and Their Control by E. Hainsworth, Heffer, Cambridge (1952).

I.T.A. Encyclopaedia Serials :

No. 64/1 under I.3.—Violet root rot by K.C. Sarmah (1959).

No. 70/1 under I.3.—Control of Primary Root Diseases of Tea by P.M. Glover and K.C. Sarmah.

No. 87 under I.4.—Lightning by K.C. Sarmah (1951).

No. 91 under I.2.—Key for Identification of the Commoner Root Diseases of Tea by K.C. Sarmah.

Tocklai Newsletter "Two and A Bud" Vol. IV, No. 1, March, 1957.

Chapter Three

STEM DISEASES AND THEIR CONTROL

NECTRIA spp. (*N. cinnabarina* (Tode ex Fr.) Fr. and *Nectria* sp.)

(Plate 9)

Nectrias are wound parasites. Several species of *Nectria* occur on tea and shade tree branches all over North-east India but so far only two have been found to be harmful; others are mostly saprophytic. They usually attack mature tea: young tea below 5 years is very rarely affected.

Nectria affected branches die back from the seat of infection but it is only the weak, unhealthy tea which suffers the most.

Nectria produces several kinds of spores, only two of which are discernible to the naked eye. Imperfect stage appears, on the bark of affected stems, as small, pinkish, soft cushions about the size of a pinhead. The perfect stage (perithecia) consists of small globules, cinnabar to crimson red, about 1/120 —1/60 inch (0·2—0·4 m.m.), across, produced singly or in groups intermingled with the conidia. They may also be produced in cracks and crevices of the stem and on the exposed wood of cuts and wounds.

Distribution of the disease takes place through air-borne spores.

Control

Affected branches should be pruned to a point not less than 4″ (10 cm.) below the lowest limit of die-back. This should only be done between middle of November and end of December. Avoid cutting out *Nectria* affected wood at other times of the year.

If the area is large, the cuts should be sprayed within 24 hours of the operation with 5% 'Ovicide' supplied by Messrs. Imperial Chemical Industries (India) Ltd., or 0·5% solution of a suitable copper fungicide. If only a small number of bushes is involved, the cuts should be painted within 24 hours with 1 oz. (28·3 grms.) copper fungicide in 20 ozs. (·566 litre) of water. This should be followed 2 or 3 days later by painting the bigger cuts with Indopaste or Indophalt.

Tea barked by hail or bark eating caterpillars, especially in places where there is history of *Nectria* attack, should be thoroughly sprayed with a 0·25% copper fungicide preferably within 24 hours of the damage. The efficiency of the spraying treatment falls off rapidly after 48 hours.

PLATE 9

1. *Nectria* sp.—(A) red perithecial fructifications, and (B) pinkish conidial cushions.
2. *Aschersonia* sp.—fructifications on the stem and green leaves; note the difference between these and the conidial fructifications (B) of *Nectria*.

Branch canker (*Poria hypobrunnea*). Note brown, corky fructification on the stem.

The general health of the tea should be improved by judicious cultural and manurial treatments. Weak tea should be allowed to build up its reserves, before medium pruning, by resting for at least 2 months.

Branches of shade trees dying back in *Nectria* affected section should be removed before general pruning of the tea commences.

Nectria ochroleuca (Schwin.) Berk.—Saprophytic.

This *Nectria* is extremely common on tea stems killed by other causes. It does not attack healthy wood.

It differs from the parasitic *Nectrias* in having cream to buff coloured or pinkish perithecia.

No treatment for this *Nectria* is necessary.

There are several saprophytic species which produce perithecia of almost the same colour as the parasitic ones.

Their parasitism can be ascertained only by inoculation tests.

BRANCH CANKER (*Poria hypobrunnea* Petch)

(Plate 10)

This is the most widely prevalent stem disease of tea and many other plants in all the tea growing areas of North-east India. It is a wound parasite which gains its entrance into the frame of the bush through wounds, especially on thicker branches, caused by various agencies. These are heavy pruning cuts, sunscorched lesions, damages with ragged surfaces made by carelessly chopping, sawing or wrenching off branches or by falling of shade trees, wounds made by hail, cattle etc., etc. On weak bushes, even wounds on smaller branches may be affected by the disease since they do not heal over within a reasonable time.

The disease gradually extends down the branches killing them one by one until it reaches the main stem and finally the roots when the whole bush is killed completely. It may take 8—15 years to kill a mature tea bush while younger bushes may be killed in 2—3 years (see under Root diseases, page 16).

It causes the affected wood to turn yellowish, soft and decay. Thin, irregular, brown lines are formed in the wood. It produces a yellowish to fawn coloured, later dull grey, corky incrustation on the underside of big branches at their base or at the collar region. This is the fructification of the fungus. Infection spreads through air-borne spores.

Control

Careful removal of all dead wood from the bushes at each pruning is necessary to control this disease. Medium pruned tea should be protected from sun-scorch damage by providing adequate shade by green cropping in alternate lines running either North—South or North-west to South-east.

Tea should be carefully desnagged in the season following medium pruning, cutting out dead portions to clean healthy wood.

All cuts and wounds, especially on thicker branches should be smoothed off with a sharp knife and then painted with a bitumen paint, such as Indopaste or Indophalt, to protect them from weather.

Removal of dead and dying branches by labour should be sternly discouraged.

THREAD BLIGHT (parasitic)

(Plate 11)

This fungus has not been given a scientific name as its fructifications have not been found so far.

The fungus produces chalky-white, branching threads or strands on the stems. These threads grow upwards along the stem and *via* the leaf stalk to the undersurface of the green leaves where they spread out fan-wise. The leaves then die and remain hanging on the stems, being held by the white threads. Mycelia enter into the stem tissues through the leaf scars and the stems are then killed.

The disease is prevalent throughout the whole of North-east India. It attacks all teas, from about 3 years upwards, growing in heavily shaded, damp, cool places and occurs year after year on the same bushes if not controlled. It is carried over from one season to another by means of the white threads which remain dormant during the cold weather.

The disease spreads mainly by direct contact. Diseased material is also distributed by wind, birds etc.

Control

Regular cleaning out of the bushes following pruning, reduction of over-dense shade and clearing of jungle adjoining the tea, to allow free circulation of air, considerably reduces the incidence of the disease and in most cases will control and finally eradicate it.

It may, however, be necessary, where the attack is severe, to supplement these operations by two rounds of prophylactic spraying with a suitable copper fungicide, using 1 lb. (·453 kilo) fungicide in 40 gallons (181·8 litres) of water, plus a wetting agent. The best time of spraying is between mid-April and end of May with an interval of two weeks between the 2 applications. The spray should be directed to the stems and the undersurface of the leaves.

THREAD BLIGHT (epiphytic)-*Marasmius pulcher* (B. & Br.) Petch.

This thread blight is difficult to distinguish from the parasitic one as the white threads are almost similar to the naked eye. The only visual difference is that the threads

Thread blight (parasitic). Note white threads on the stem and fan-like film of white mycelium on the undersurface of the leaves.

in this case spread out to a film on the stem and grow as threads on the undersurface of the leaves, just the reverse of the parasitic Thread blight.

Some of the badly affected leaves die after a time but it is not known whether or not their death is due to the direct effect of the fungus. Dead leaves remain suspended, on the stems, by the fungal threads. The fungus has not been found to penetrate into live tissues.

The growth of the fungus is favoured by the same set of conditions as in parasitic Thread blight. It is found not only on tea but on many jungle plants including grasses and weeds.

It produces its fructifications in the form of small, white, cup-like structures and small, helmet shaped, white umbrellas on dead litter on the ground.

Distribution of the fungus takes place through wind-borne spores and diseased material.

Control.

Although the fungus is apparently harmless it is best treated in the same way as parasitic Thread blight since it is difficult to differentiate between the two in the field.

PINK DISEASE—*Pellicularia salmonicolor* (B. & Br.) Rogers=*Corticium salmonicolor* B. & Br.

This fungus is closely allied to the Black rot fungi of tea. It has been found on rare occasions to attack young tea plants in Cachar and Sylhet districts. It is practically unknown on tea elsewhere in North-east India. The disease, however, is common on *Crotalaria anagyroides* and *Tephrosia candida* in Assam.

It produces a thin film of silky-white mycelium on the stem. The fungus also penetrates into the live tissues.

On *Crotalaria* and *Tephrosia* plants fructification appears as a thin, rosy-pink crust with cracks formed at right angles to one another at frequent intervals. The crust is usually produced on the shaded side of the stem but sometimes it is found surrounding the whole stem. The affected plant wilts and dies. On tea, fructifications are extremely rare.

Control.

Affected stems should be cut out and burnt and the bushes then sprayed with a 0.25% suspension of a suitable copper fungicide.

Diseased *Crotalaria* and *Tephrosia* plants should be pulled up and burnt. If it occurs on these green crops in young tea areas including nurseries the latter should be thoroughly sprayed with the above fungicide.

THORNY BLIGHT—*Aglaospora* sp.

(Plate 8)

This disease is very common in Darjeeling, less so in Terai and the Dooars and rare in Assam. It is a disease of weak bushes.

It gains its entrance through pruning cuts and wounds on the stems and is therefore a wound parasite. It travels downwards slowly, killing the branches one by one until it reaches the collar and finally the roots when the bush is completely killed (see under Root diseases, page 15).

The fungus does not produce any external mycelium. Fructifications appear on the bark as small swellings with a black, pointed, thorn-like projection, about 1—1.5 mm. long, in the centre; the swellings (perithecia embedded in the bark) occur either singly or in groups. Wood of the stem is marked with blackish patches and black lines. Small, dull white, strands (almost similar to those of Black root rot) are sometimes seen on the wood surface, when the bark is peeled off.

Control.

Cut out the diseased stems to clean, healthy wood. Smooth off the cuts and paint them with Indopaste or Indophalt.

The general health of the tea should be improved by judicious manuring and cultural operations.

Weak areas, intended for medium pruning should be rested for at least 2 months prior to the opertion. Tea should be thoroughly desnagged in the year following medium pruning and the bigger cuts painted with Indopaste.

MACROPHOMA THEICOLA Petch (= *Physalospora neglecta* Petch)

This disease is prevalent mostly on tea in drought susceptible areas, in the plains, especially where the soil is light, sandy and/or stony. It is very rare in Darjeeling. Tea subjected to Sun-scorch is also liable to attack.

Diseased patches on the branches, appear as slightly sunken lesions surrounded by a ring of callus growth. Sometimes the callused ring is killed by the fungus, when a second or even a third ring of callus may be formed a little further away. The bark and the wood tissues to some depth inside the callused rings are killed by the invading fungus. Affected bushes are killed slowly, at first branch by branch, until the disease reaches the collar when the whole of the upper portion dies.

Fructifications of the fungus are tiny, black receptacles (*perithecia* and *pycnidia*) produced in the dead bark during the rains. They look like minute cavities, filled with a white substance, when scraped with a knife.

The fungus is disseminated by wind-borne spores.

It has also been found to attack *Albizzia falcata* (=*A. moluccana*), *A. odoratissima*, *A. procera*, *Dalbergia assamica*, *Millettia dura* and *Tephrosia candida*.

Control.

Diseased branches should be cut out to clean, healthy wood, where possible.

Since the disease is secondary following drought and sun-scorch damage precautionary measures should be adopted to protect the tea from such damage by providing adequate shade, ground cover etc. where necessary.

General health of the tea should be improved by correct manuring and cultivation.

JEW'S EAR FUNGUS—*Auricularia auricula* (Hooke) Underwood.

The fungus is a weak, wound parasite which infects the tea plant, through wounds on thicker branches, in the same way as *Poria hypobrunnea* and sometimes accompanies it. Its occurrence is rather rare but its effect on the tea bush is similar to that of *Poria*, though less severe.

The fungus does not produce any external mycelium by which its presence can be detected. It, however, produces during the rainy season soft, flesh coloured, gelatinous, human ear-like brackets about 1—3 inches (2.5-7.5 c.m) across which are very characteristic.

Control.

Cutting out dead branches to clean healthy wood and painting the cuts with a protective paint like Indopaste is all that is necessary.

VELVET BLIGHTS—*Septobasidium bogoriense* Pat., *S. theae* Boed. & Stein., *S. tuberculatum* Boed. & Stein., *S. pilosum* Boed. & Stein. etc.

All the species of *Septobasidium* have been found to parasitise scale insects. These fungi are wholly external and they do not attack the tea plant.

Velvet blights are more common in the hills than in the plains gardens. They occur on the living branches as smooth, velvety lumps or continuous sheets or felts, woolly coverings etc. Occasionally such growths spread out to some distance on the undersurface of the green leaves, *via* the leaf stalk. They are of varying colours such as, white, yellowish-brown, purplish-brown, grey, bluish or black.

Fructifications of the fungi are produced directly on the velvety felts. The fungi spread mostly by means of infected young scale insects.

Control.

Since Velvet blights are always associated with scale insects they are easily eradicated by getting rid of the latter by one of the following methods.

1. Affected bushes should be sprayed with 'Ovicide' (marketed by I.C.I.) 2% plus a spreading agent, taking care to wet the affected branches thoroughly. Two or three applications at intervals of 10—15 days may be necessary.

2. Affected branches should be painted with 1.5—2% Caustic wash which should be followed by spraying, after about a week, with a standard Lime-sulphur solution using 1 part Lime-sulphur in 30 parts of water.

ASCHERSONIA Sp.

(Plate 9)

This fungus, like the Velvet blights, parasitises scale insects. It is common on all teas throughout the whole of North-east India. The fungus, however, is harmless to tea.

It produces hard, isolated, yellowish-red, orange-red or pinkish-red lumps, up to about $\frac{1}{4}''$ (6.3 mm.) across (usually much smaller), on green or old living stems and occasionally on the undersurface of green leaves. These lumps are sometimes confused with the conidial fructifications of *Nectria*.

The fungus spreads probably by means of air-borne spores.

Control.

The fungus disappears soon after the scale insects are eradicated (see under Velvet blights).

LEADING SYMPTOMS OF STEM DISEASES.

(1) *Nectria* spp.—(a) parasitic, (b) saprophytic.

(a) Branches die back, they often have a greenish appearance.

Groups of small, pinkish lumps or cushions, about the size of a pin-head are produced on the stem.

Crimson or cinnabar red, tiny globules are produced in cracks and crevices, pruning cuts, hail cuts and also on rare occasions on the undamaged bark.

(b) Groups of small pinkish lumps or cushions as in (a). Also cream coloured or light rosy, tiny globules occur among the pinkish lumps or nearby.

(2) **Branch canker**—*Poria hypobrunnea* Petch.

Bushes partially or wholly dead. Wood yellowish, soft, rotten, marked with thin brown lines. Film of yellowish-brown mycelium between the bark and the wood, also

inside the latter. Small yellowish-brown cushions on the stem surface. Brown corky encrustation dotted with tiny, regular pores usually on shady side of the stem.

(3) **Thread blight**—(a) parasitic, (b) epiphytic.

(a) Chalky-white, twine-like, branching thread runs along the stem, travels *via* the leaf stalk to the undersurface of the leaves where it spreads out fan-wise. Withered leaves hang on to the stems.

(b) Chalky-white thread or film of mycelium spreads along the surface of the stem and *via* the leaf stalk to the undersurface of the leaves where it spreads out as white, twine-like, branching threads. Withered leaves hang on to the stems. Fructifications are either white, small, cup-like structures or small, white, helmet shaped umbrellas.

(4) **Pink disease**—*Pellicularia salmonicolor* (B. & Br.) Rogers
=*Corticium salmonicolor* B. & Br.

Silky white film of mycelium on the stem.

On *Crotalaria anagyroides* and *Tephrosia candida* stems it produces a thin, rosy-pink encrustation with small cracks formed at right angles to one another.

(5) **Thorny blight**—*Aglaospora* sp.

Small swellings provided with a thorny, black, pointed beak about 1—1.5 mm long, occur singly or in groups in the bark of the stem.

Small, dull-white strands between the bark and the wood. The latter is marked with black lines and inky-black patches.

(6) *Macrophoma theicola* Petch.

Longitudinal, dead lesions surrounded by one or more rings of callus on the stem. Affected bark when scraped with a knife shows tiny cavities filled with a white substance.

(7) **Jew's ear fungus**—*Auricularia auricula* (Hooke) Underwood.

Soft, flesh coloured, gelatinous, human ear-like, brackets 1—3 inches (2.5—7.6 cm.) across on the stem.

(8) **Velvet blights**—*Septobasidium* spp.

Smooth, velvety, superficial lumps or felts of mycelium of varying colours, such as white, yellowish-brown, purplish-brown, grey, bluish-grey etc., also black, woolly covering, on living stems.

(9) *Aschersonia* sp.

Small, hard, isolated, yellowish-red, orange-red or pinkish-red lumps on living stems and on the undersurface of green leaves.

References.

I.T.A. Memorandum No. 16—Notes on Stem Diseases of Tea in N.E. India by A.C. Tunstall and K.C. Sarmah (1947).

I.T.A. Tea Encyclopaedia Serials :
No. 42/2 under I.3.—Thread blight by K.C. Sarmah and P.M. Glover.

No. 65/2 under I.3.—Branch Die-back and *Nectria* by K.C. Sarmah and P.M. Glover.

No. 68/1 under I.4.—Branch canker (*Poria hypobrunnea* Petch) following Sun-scorch and Branch damage by K.C. Sarmah.

No. 113 under J.3.—Scale Insects and Mealy bugs on Tea bushes by G.M. Das.

Tea Pests & Diseases and Their Control by E. Hainsworth, Heffer, Cambridge (1952).

A B C

Black rot (*Corticium theae*). Note suspended diseased leaf and fungal thread on the stem (A), white, powdery fructifications on the under surface of the leaf in (B) and (C).

Chapter Four

LEAF DISEASES AND THEIR CONTROL

BLACK ROT—*Corticium invisum* Petch and *C. theae* Bernard.

(Plate 12)

Black rot disease is caused by the two fungi noted above. They not only produce the same effect on the tea bush but also sometimes occur together.

The disease is very common in the plains and it is rare in the hills. It attacks all teas from their seedling stage upwards.

The disease persists in the same areas for years, if not controlled, causing gradual deterioration in the health of the tea and loss in crop. It thrives best and persists for years in the badly ventilated places, often where air movements are prevented by bamboo baries, under overdense shade or areas surrounded by jungle, especially where the air in the rainy season is hot, moist and still. Black rot is more prevalent on tea which has been cut across without any cleaning out and on skiffed and unpruned tea.

Corticium invisum produces on the leaves irregular patches with a slightly raised wavy margin. These patches are often accompanied by many small, greyish-white, more or less circular spots. Colour of the larger patches is a mixture of brown, yellowish to chocolate brown and grey on the uppersurface; the undersurface is evenly brown or grey. Diseased patches and young affected leaves look black and slimy when wet.

Diseased leaves often remain attached, to other leaves and stems, held together by small cushions or films of pinkish-white or cream coloured mycelium. The fungus produces minute resting bodies (*sclerotia*) in the cracks and crevices of the stem towards the end of the rainy season. Fructifications appear, during the rainy season, as white, dusted patches on the undersurface of mature, green leaves.

Corticium theae produces on the leaves large patches covering about half and sometimes the entire leaf area. Colour on the uppersurface of the affected area at the early stage is reddish-brown, similar to sun-scorch damage, later it is a mixture of brown, yellowish-brown and grey; the undersurface is light brown or greyish-white and usually covered with a net work of cream to brown mycelium.

The fungus produces on the stems, thick cords of mycelium, up to about 3 mm. across, dark purplish-brown on the older portions of the stem and dull white to light brown on the green portion at the top.

Dead leaves remain suspended onto the stems, held by the mycelial cords.

Fructifications appear as powdery white patches on the undersurface of apparently healthy green leaves.

Black rot fungi spread not only by direct contact from bush to bush but also by the distribution of diseased material by wind, birds, workers etc., and air-borne spores.

Besides tea the disease has been recorded on *Albizzia amara*, *A. chinensis* (=*A. stipulata*), *A. lebbek*, *A. procera*, *Aleurites* spp., *Cajanus indicus*, *Calapogonium mucunoides*, *Centrosema plumieri*, *Crotalaria anagyroides*, *Desmodium gyroides*, *Erythrina* spp., *Stylosanthes guyanensis var. gracilis*, *Tephrosia candida*, *T. vogelii*, and several grasses and weeds.

Control.

Affected areas should be sprayed prophylactically, with 0.25% suspension of a suitable copper fungicide mixed with a spreader, twice at an interval of two weeks during mid-April to end of May. Thereafter individual bushes should be sprayed again whenever Black rot attack is observed.

In spraying bushes affected by Black rot it is essential to wet the undersides of the leaves and the frame thoroughly with the fungicide.

Overdense shade should be reduced and ventilation improved by cutting back jungle, where possible.

Cut-back or heavy pruned tea should be painted with a caustic wash, immediately after pruning.

BLISTER BLIGHT—*Exobasidium vexans* Massee

(Plate 13)

This disease is prevalent throughout the whole of North-east India but its main period of occurrence in the different regions is as follows :

Darjeeling	June to September.
Dooars	September to November.
Assam Valley & Cachar	March to May.

Severe outbreaks may, however, take place when favoured by climatic conditions, at other times of the year also, *e.g.* in early spring in the Dooars and early cold weather in Assam.

The disease attacks young succulent growth (leaves and stems) on all teas including young seedlings especially under heavy shade and in areas where the air is moist and cool.

The fungus produces on the first three leaves pale yellowish, circular spots, up to about $\frac{1}{2}$" (12.7 mm.) in diam., which are glistening and concave on the uppersurface

Blister blight (*Exobasidium vexans*). Note white blisters on the undersurface of the leaf on the left and 2 white stem blisters on the right, also concave spots on the upper surface of the leaf on the extreme right.

and white or pink, powdery and convex on the underside. On the succulent stem the diseased patches are white and powdery. Actually at this stage the fungus produces its spores. When several patches occur on a single leaf it becomes curled and distorted. The attack on the stem causes it to bend over; sometimes it breaks off at the affected portion.

The spores are extremely minute structures, so much so that a single blister less than $\frac{1}{2}$" (12·7 mm.) in diam, produces many thousands of them at a time. These spores are carried by the wind to scores of miles. They do not remain viable for long in hot, sunny weather but when they are borne during a cool, wet or dull period and deposited on the tea they are capable of germinating and infecting the young, succulent growth in the course of a few hours, provided they get sufficient moisture.

A single spore can produce an individual blister. The spore on germinating produces a tiny thread-like projection which forces its way through the epidermis into the soft tissues where it rapidly branches into tiny mycelial filaments. These filaments grow inside the host tissues, deriving all the nourishment from them, for about 7 days without showing any visible sign of infection. Then the affected patch appears as a yellowish, glistening, circular spot. After about 10-18 days from the time of infection the fungus begins to produce spores which are borne in vast numbers on tufts of mycelial projection on the undersurface of the leaves. This gives the white, powdery appearance to a blistered spot.

The white, powdery stage, during which the new spores are liberated may continue for about 7 or 8 days before the fungus begins to die. This is indicated by blackening of the blistered area.

The foregoing clearly indicates that by the time a blistered spot is about to die the leaf on which it is formed may be 3—4 weeks old and fairly hard. People often believe, when they come across such a leaf lower down on the frame or on a side shoot, that the disease is also capable of attacking older leaves but it is not so.

Now the question arises, where do these spores come from? There are two probable answers.

Firstly, in rare cases, Blister blight is known to be carried from one season to another, (1) in disused seed baries situated in damp, cool places, (2) abandoned tea, (3) abandoned old nurseries or stray old nursery plants left over and forgotten in heavily shaded jungle areas, which form local sources of infection.

Secondly it is possible, nay quite probable, that the fungus thrives on wild tea in the Himalayan foot hills and the spores are carried down to the plains by wind. Outbreaks occurring from such sources are usually of an epidemic nature.

As it is quite impossible to wipe out all the wild tea in the hills it is evidently not possible to avoid Blister blight epidemics. The only thing we must be prepared to do is to protect our teas from damage by suitable cultural practices and direct control measures. We can, however, eliminate the local foci of infection.

So far no other alternative host for the tea Blister blight has been discovered anywhere. Many jungle plants are believed to act as alternate hosts but there is no proof.

Control

Young, succulent growth on the tea plant is the only portion susceptible to attacks of Blister blight. Hence the most important factor in controlling this disease is either to remove succulent growth as fast as it is produced where possible or to protect such growth by spraying with a copper fungicide at 0·25% concentration at regular intervals of 7—10 days, until it hardens up or the disease disappears.

Young nurseries must not be defoliated. They should be protected by spraying at regular intervals of 7—10 days.

The disease can be disastrous on tea recovering from pruning. If it occurs along with bud-break on medium pruned or cut back tea the first two rounds of spraying should be done at an interval of 4 days at bud-break and the subsequent ones at weekly intervals until a sufficiently hard maintenance leaf table is formed. Outbreaks on such tea, occurring sometime before it is due for tipping, may be checked by tipping the tea below the intended level and protecting the young growth lower down by spraying as above. The plucking level may be raised to the desired level by leaving a leaf or two later in the season when the danger period is over.

Reduction of over-dense shade will help considerably to reduce the intensity of attack.

Where spring outbreaks are of usual occurrence, medium pruning might be adjusted so as to obtain a hard leaf table before the blister period comes but this operation is very risky in drought prone areas.

When the disease occurs in the autumn, on a small number of bushes, pull off and destroy the affected leaves. Large areas should either be pruned or skiffed.

On early sample pruned bushes if only a few leaves are affected these should be plucked off. If the attack is severe the bushes should be sprayed with a copper fungicide on a ten-day round.

Labourers working on Blister blight control should not be allowed into unaffected Tea.

Do not attempt to carry away diseased material; it should be dropped on the ground.

BOTRYTIS sp.

This disease is rather rare but it is important when it occurs on young tea. It sometimes attacks the flowers of *Crotalaria anagyroides* and when the affected flowers drop on young, succulent growth on tea growing underneath it attacks the latter. Harder leaves and stems are not affected.

It produces on fully opened, soft leaves irregular patches, both small and large, bright reddish-brown in colour on both the surfaces, zonated towards the edge, encircled by a translucent, watery ring up to about 1 mm. wide; a dead *Crotalaria*

PLATE 14

Brown blight (*Colletorichum camelliae*).

PLATE 15

Grey blight (*Pestalozzia theae*).

flower usually remains attached. Affected lesions on the stem are brownish-black encircled by a swollen ring.

Botrytis conidia appear on the undersurface of leaves as tiny, white tufts.

Control

Pluck off the diseased leaves. Lop the *Crotalaria* as soon as the disease is noticed. Infection by air-borne spores is negligible hence no other treatment is necessary.

BROWN BLIGHT—*Colletotrichum camelliae* Mass.
AND =*Glomerella cingulata* (Stonem) S. & v. S.
GREY BLIGHT—*Pestalozzia theae* Sawada.

(Plates 14 and 15)

These diseases are extremely common on old tea leaves that are about to fall and also on leaves of all ages when the tea plant is weakened by other causes such as (1) severe attack of Red spider and Jassids (Green fly), (2) overdose of chemical manure, (3) lack of nitrogen, (4) waterlogging, (5) sun-scorch, (6) hail damage, (7) lack of shade, (8) drought and (9) hard plucking etc.

Both the diseases are prevalent throughout the whole of North-east India and in most cases they occur together.

Brown blight

The diseased patches usually start at the margin of the leaves and spread inwards. When two or more patches occur side by side the whole leaf may be affected. The edges of the patches are sharply defined and more often marked with a delicate concentric zonation. The colour on the upper surface is yellowish to chocolate brown at first, gradually changing to grey from the centre outwards. Minute, black, scattered dots (the fructifications) appear on both sides of the diseased patch.

Grey blight

The diseased patches are light to dark brown, with a greyish centre on the upper surface, roughly circular to oval, marked with concentric zonations almost from the centre to the very edge. Black pustules (fruit bodies) somewhat bigger than those of Brown blight are produced in concentric lines on the uppersurface.

The diseased patch may occur at the margin or in the middle of the leaf. On old leaves it starts from any damage—a cut, a break or a bruise—on the leaf blade. On young leaves the patch is usually dark brown to almost black, rather irregular in shape and not marked with concentric rings.

Control

Direct fungicidal treatment is not necessary in any of these cases. The predisposing cause(s) of attack should be ascertained and the tea treated accordingly.

SOOTY MOULDS—*Limacinula theae* Syd. & Butl., *Capnodium* sp., *Meliola* sp. etc.

Sooty moulds are found everywhere in North-east India. Their presence is always associated with insects, mainly scale insects.

The fungi produce, on the uppersurface of the tea leaves, an entirely superficial coating which is either a thin film or a woolly or powdery growth, soot-like in appearance. The film peels off in flakes when dry. The fungi do not derive nourishment from the tea plant; they grow on the sticky, sugary secretions (honeydew) of various insects living on shade trees or green crops overhanging the tea or on the tea itself. They are, however, not entirely harmless as they interfere with the normal functions of the tea leaves by cutting off the light with their compact, black covering.

Control

Fungicidal treatment is hardly necessary since the fungi disappear soon after the eradication of the insect(s) concerned either by lopping off the infested shade tree branches or by removing the insect affected green crop.

If they occur as a result of scale insect attack on the tea itself the latter should be sprayed either with 'Ovicide' or Lime-sulphur solution to get rid of the scales (see page 30).

LEADING SYMPTOMS OF LEAF DISEASES

1. **Black rot**—(a) *Corticium invisum* Petch and
(b) *Corticium theae* Bernard

(a) Groups of small, more or less round, brown to grey spots which coalesce to form bigger, irregular patches with a slightly raised, wavy margin. Bigger patches are mottled with yellowish, brown and grey on the upper surface. Diseased leaves stick to other leaves and stems, held by mycelial filaments or cushions.

White powdery patches, as if dusted, on the undersurface of mature, green leaves.

(b) Thick strands of mycelium, up to about 3 mm. broad, purplish-brown on older stems and dull white to light brown on the green portion.

A large portion or the entire area of the leaves reddish or yellowish-brown, resembling Sun-scorch, later changing to a mixture of brown, yellowish-brown and grey. Diseased leaves remain suspended or stick to other leaves and stems, held by mycelial threads.

White, powdery patches, as if dusted, on the undersurface of mature, green leaves.

2. **Blister blight**—*Exobasidium vexans* Massee

White, sometimes pink, powdery, round or oval, convex warts, about $\frac{1}{2}$ inch (12·7 mm.) in diam, on the undersurface of young, succulent leaves; corresponding spots on the uppersurface concave, yellowish and glistening. Severely affected leaves curl or bend over.

Patches on the succulent stem are elongated, slightly swollen, white and powdery. The stem at this point bends over or breaks off.

3. *Botrytis* sp.

Bright reddish-brown, irregular patches of varying sizes, zonated towards the edge, encircled by a watery ring about 1 mm. wide, on fully opened, soft leaves.

Patches on the green stem are brownish-black and encircled by a swollen ring.

4. **Brown blight**—*Colletotrichum camelliae* Mass.

Yellowish or chocolate brown to greyish, well defined patches, concentrically zonated at the edge and dotted with minute, scattered, black dots on both the surfaces of the leaves.

5. **Grey blight**—*Pestalozzia theae* Sawada.

Light to dark brown, circular or oval, concentrically zonated patches bearing black pustules in concentric lines on the uppersurface.

6. **Sooty moulds**—*Limacinula theae* Syd. & Butl.,
Capnodium sp. and *Meliola* sp.

Thin, soot-like black, woolly or powdery, superficial film, on the uppersurface of the leaves. The film peels off in flakes when dry.

FLOWER DISEASE OF TEA.

In the course of examining tea seed trees, with a view to ascertaining the cause of poor setting of fruits, a fungus producing *Botrytis* conidia was observed, during the flowering season on most of the withered tea flowers. The fungus belongs to the family *Sclerotiniaceae*. Some fungi belonging to this family are known to cause diseases of flowers and fruits in orchards and of *Camellia* flowers, in other parts of the world.

Our investigations have shown that in and around Tocklai, there are more than 2 dozen hosts on which a similar fungus occurs about the same period (November to March.)

So far it has not been possible to establish conclusively the pathogenicity of the fungus by direct inoculation of tea flowers in the field due to technical difficulties. Trials, therefore, of a purely applied nature have been conducted assuming the fungus to be responsible for the non-setting of tea fruits.

It has been observed that along with *Botrytis* a number of fungi occur more less to the same extent on tea flowers. It appears that these fungi, including *Botrytis* spp., are colonisers of a declining substratum.

References.

I.T.A. Memorandum No. 19—Black rot of Tea in N.E. India, by A. C. Tunstall & K.C. Sarmah (1947).

I.T.A. Tea Encyclopaedia Serials :

No. 8/2 under I.3.—Black rot by K.C. Sarmah.

No. 62/1 under I.3.—Blister blight by K.C. Sarmah and P.M. Glover.

No. 63/1 under I.3.—Brown blight and Grey blight by K.C. Sarmah.

No. 113 under J.3.—Scale insects and mealy bugs on tea bushes by G.M. Das.

Tea Pests and Diseases and their Control, by E. Hainsworth, Heffer, Cambridge (1952).

Annual report Mycology Branch 1957—1959

Tea Quarterly, The Journal of the Tea Research Institute of Ceylon, Vol. XXII, Part II June, 1951.

Chapter Five

SEEDLING DISEASES AND THEIR CONTROL

COLLAR ROT—*Phomopsis* sp.

This fungus is common in tea nurseries throughout the tea growing region of North-east India. It occurs mostly in the soils which are of a sticky nature or where a hard crust forms on the surface after heavy rains.

The fungus attacks young seedlings, (up to about 9 months from the time of emergence) at their collar region, encircling the main stem in a ring and extending over a region of 1—2 inches (2.5—5.0 cm.) above and about $\frac{1}{2}''$ (1.27 cm.) below the soil level. Occasionally the attack takes place a little above the soil surface.

The affected portion of the stem is usually smaller in girth than the adjoining unaffected portions on either side. The upper edge of the diseased area is marked by a ring of callus growth which pushes the bark up. If the diseased portion is scraped with a knife, the wood is found to be discoloured either brown or bluish, sometimes permeated with thin black lines or rings. Fructifications of the fungus appear as minute, black dots scattered over the affected bark.

Affected seedlings suddenly wilt and die, when a hot sunny period prevails, towards the end of the rainy season. Deaths occur either in groups or in a scattered manner.

Control.

Nothing can be done to save the diseased seedlings. Slightly affected ones may survive for a few seasons until they are subjected to attack by other fungi through the damaged tissues or to some adverse conditions of growth.

Measures must, therefore, be of a preventive nature. Nursery beds, especially in unshaded, sticky soil, should be sprayed, with a 0.25% suspension of a suitable copper fungicide, once before the heavy rains are expected and again after about a month, in a lull in the rains. Care should be taken to wet the collars of the seedlings with the spray fluid. The surface crust should be lightly broken before spraying.

'DAMPING OFF'—*Pythium* sp.

This soil fungus is known to occur in tea nurseries in the plains of North-east India, where the soil is sticky, tending to form a crust on the surface after heavy rains or where the soil remains unduly wet for long periods.

The fungus attacks the main stem, of young seedlings, near the soil surface, as in the Collar rot caused by *Phomopsis*. Infection occurs, while the stem is still soft, *i.e.* during the first 6 months, immediately below the surface crust. The stem is affected all round to about an inch (2.5 cm.) above and the root to about 2 inches (5.0 cm.) or more below the soil level.

The bark of the affected region becomes very soft so that it crumbles away when rubbed with the fingers. The wood, when scraped with a knife appears sodden and slightly discoloured. The disease does not produce any other external symptom.

Diseased seedlings look yellowish and unhealthy during the rainy period and suddenly wilt and die when a period of hot, dry weather prevails towards the end of it.

Control.

Nurseries in heavy soils, should be sprayed, prophylactically, so as to wet the soil round the collar of the seedlings, with Cheshunt compound*, once after the first heavy rains and again after about 3 weeks of the first application. Failing this the beds should be sprayed as soon as signs of *Pythium* attack are noticeable, to be followed by a second application after about 10 days. If there is any crust formation on the surface of the beds it should be lightly forked and the soil splashings adhering to the stem of the seedlings should be lightly rubbed off with the fingers before spraying. If the ingredients of Cheshunt compound are not available, a 0.25% suspension of a copper fungicide may be substituted.

Do not water nurseries with dirty water from shallow ponds or pools.

Do not use rice-straw as a ground cover on nursery beds. It is known to favour the attack of 'Damping off' fungus.

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* *Cheshunt Compound*—Copper sulphate 2 parts
Ammonium carbonate 11 parts } by weight.

Grind the substances separately to a fine powder and then mix. Store in a stoppered, non-corrosive container for 24 hours before use.

For use 1 lb. (·453 kilo) of the mixture is dissolved in 30 gallons (136.3 litres) of water.

Chapter Six

DISEASES CAUSED BY PARASITES OTHER THAN FUNGI

BACTERIAL DISEASE

So far no bacterial disease has been found on tea plants in North-east India.

Tea seeds, damaged by the tea seed bug (*Poecilocoris latus*), are often invaded by bacteria but these are secondary.

A wilt disease of nursery seedlings of *Gliricidia sepium* (=*G. maculata*) and Tung (*Aleurites* sp.), caused by bacteria has been rocorded at Tocklai.

Control.

No effective control measures against bacterial wilt are known.

VIRUS DISEASE

No virus disease of tea of any commercial importance is at present known in North-east India.

Tephrosia candida is known to be affected by more than one virus disease. The following symptoms are produced on the affected plants.

(i) The leaves become variegated and mottled with yellow spots.

(ii) Plants become crinkled and dwarfed.

(iii) Plants grow normally for sometime and then develop bunches of witche's-broom-like growth with swollen, crinkled, weeping shoots and miniature, yellowish leaves.

Virus diseases are known to be transmitted by insect vectors.

Control.

Affected plants should be uprooted and destroyed.

RED RUST—*Cephaleuros parasiticus* Karst.

(Plate 16)

This is a disease caused by an alga NOT by a fungus and the name Red rust is therefore a misnomer. This secondary disease is common everywhere in the plains and it attacks all kinds of tea both young and old when vitality is impaired by adverse conditions of soil, climate etc. These are mainly poor fertility, alkalinity and lack of aeration of the soil, hard pan, inadequate or complete absence of shade, drought and waterlogging.

Red rust causes severe damage, especially to young tea by attacking and killing stem tissues in patches. This results often in die-back of the stems. Older leaves and tea seed capsules are also attacked but here the damage is negligible.

Affected patches on the stems become most noticeable when the alga produces its main crop of fructifications, which, appear about April—July on one or two year old, sometimes on three–year old, stems. The fruiting patches are brick-red or orange in colour. When examined with a pocket lens these are seen to consist of a dense growth of tiny, orange coloured hairs†, bearing at their ends minute knobs (sporangia) inside which the spores are produced. It is not unusual to find a few such hairs at other times of the year but they generally escape notice except when produced on the affected spots on the leaves.

From about August to March Red rust lesions on the stems can be rocognised by their circular to oval shape, purplish-black colour and longitudinal cracks on the surface. The patches are mostly to be found on the upper side of horizontal branches while they occur on all sides of the vertical ones.

Infection takes place mostly during the fruiting period (April—July) by means of microscopic spores which are distributed by wind, rain splashings etc. The weather conditions at this time, being wet and warm, are ideal for the germination of the spores and for the invasion of tissues of the young stems by the algal cells thus produced. The alga, after penetrating into the tissues goes on multiplying at the expense of the host cells and gradually extending deeper and deeper. The host plant attempts to throw off the infection by growing a layer of corky tissues below the affected ones, but rarely succeeds if it is debilitated from one or more of the adverse conditions related in an earlier paragraph. As a result severely affected stems on weak bushes die back.

Tea plants attacked moderately to severely by Red rust on the stems invariably present a very characteristic appearance during the fruiting period. The leaves produced above the affected region become variegated with yellow patches.

The disease is fairly common on the older tea leaves. Affected spots are more or less circular, up to about $\frac{1}{4}''$ (6.3 mm.) in diameter, with a slightly swollen appearence on the uppersurface, the margin is purplish in colour. Sometimes a watery green ring of tissues surrounds the diseased spots. Fructifications appear at the centre of the spots either on the uppersurface or on both the surfaces, from about July onwards. Older spots become dry and the central portion turns light, dirty brown or greyish.

Red rust appears to be capable of attacking many green plants besides tea. It has so far been recorded on the following hosts which are grown in tea estates. The ones marked with an asterisk have been found to be very susceptible.

† Fruiting hairs of Red rust are often confused with those of a saprophytic fungus known as *Stilbum nanum* (see Plate 16).

1. Red rust (*Cephaleuros parasiticus*)—(A) orange-red fruiting patch, (B) longitudinal cracks on a purplish-red, old patch, (C) variegation of the leaves. 2. Tea stem showing fructifications of *Stilbum nanum*.

Acacia lenticularis, *Adenanthera pavonina*, *Albizzia chinensis**, *A. lebbek*, *A. odoratissima*, *A. procera*, *A. sumatrana*, *Crotalaria anagyroides*, *C. brownei*, *Dalbergia assamica*, *Derris robusta*, *Desmodium gyroides**, *Gliricidia sepium*, *Indigofera dosua*, *I. teysmanii*, *Melia azedarach*, *Parkia javanica*, *Priotropis cytisoides*, *Tephrosia candida** and *T. vogelii**.

Control.

Since attack of Red rust becomes severe under unsatisfactory environmental and/or cultural conditions it is essential in the first place to ascertain the predisposing cause of ill-health of the plant and remove it by appropriate treatment. This may be done in a variety of ways.

1. Improve soil fertility, where necessary, by judicious manuring. Increasing amounts of nitrogenous manure appreciably reduces Red rust, especially when potash is added to it. It is therefore advisable to manure young tea with a balanced mixture containing nitrogen, phosphate and potash.

2. Rectify the pH status of the soil where necessary.

3. Improve soil aeration by proper drainage (this is extremely important).

4. Establish good shade.

5. Drought tender areas should be irrigated or protected by other cultural measures e.g. heavy mulch dressing, effective shade, water conservation, good drainage, adequate manuring, pruning at the correct time etc.

6. Supplement treatments 1—5 by spraying the stems thoroughly with 0.25% suspension of a suitable copper fungicide, preferably mixed with a spreader or wetting agent. At least two rounds are recommended, one in the last week of April and the second in the third week of May. It may be necessary to continue the spraying for 2—3 consecutive years to ensure satisfactory control. The time of spraying may vary somewhat from year to year or district to district due to climatic changes.

On shade tree seedlings in the nursery, in areas where Red rust is known to be prevalent, the spraying should be continued at fortnightly intervals to end of June. Young shade plants in the young tea should be sprayed at the same time as the tea is sprayed. A little older ones, which cannot be sprayed without wasting a large amount of spray fluid, should be painted on the stem with a painting brush using 1 lb. (·453 kilo.) of fungicide in 10 or 15 gallons (45·46 or 68·2 litres) of water plus a spreading agent.

(7) Never allow two-year old *Tephrosias* and *Desmodium gyroides* to stand in young tea.

Whenever possible use *Crotalaria anagyroides* in preference to Boga medeloa (*Tephrosia candida*) and *Desmodium gyroides* as temporary shade in young tea as the former is very much less susceptible to Red rust attack. African medeloa (*Tephrosia vogelii*) is best avoided in young tea except as a one year crop, to be removed before the end of March.

Boga medeloa and *Desmodium gyroides* sown with the early rains in February—early March are often infected by Red rust when they are 3—4 months old, as a result

they bear a heavy crop of Red rust fructifications in April—July during the following year and thus serve as centres of infection to the young tea. Hence early sown Boga medeloa and *Desmodium gyroides* should always be removed in March of the following year.

ANIMAL PARASITES.

Tea plants and young shade tree plants are sometimes damaged on their underground portion by animal parasites such as Cockchafer grubs, Longicorn larvae and rats. Young tea seedlings in their first 9 months in the nursery are very often damaged on their roots by eelworms to such an extent that whole nurseries result in a failure.

Damage caused by animal parasites to the aboveground portion of plants can be easily recognised but that occurring below the soil surface is often confused with the effect of other factors such as drought, heat, waterlogging, manure, disease etc.

"RAGHUMALA"—*Loranthus* sp. (or *Dendrophthœ* sp.?)

This is a parasitic green plant similar to mistletoe. It is fairly common on the forest trees as well as on many of the cultivated plants including tea seed trees.

The plant grows on the branches in clumps, producing leaves which often appear to simulate those of the host. Its roots grow a long way from its point of origin. These roots firmly adhere to the surface of the branch by means of small root-like projections (suckers) which penetrate into the host tissues. Ultimately the roots completely fuse with the stem of the host plant. Since the parasite takes up its nourishment from the host the latter gradually develops die-back of the stems and if the attack is severe whole plants die out.

It is very common on tea seed trees, especially in neglected 'baries'.

"Raghumala" produces very sticky seeds, which, stick to the beak and feet of the birds feeding on them and are thus distributed from place to place. Some people believe that the seeds do not germinate unless they have passed through a bird's intestines.

Control.

The parasite should be promptly removed by cutting the affected branch well below the end of the root. Any seeds sticking to the branches of the host plant should also be brushed off at the same time.

When the affected branches cannot be removed without causing heavy damage to the tree itself the following treatment will be found very effective.

Prune off the raghumala at $1\frac{1}{2}$ to 2 inches (about 4—5 cm.) above the point at which it emanates from the host branch, making as oblique a cut as possible, so as to leave a stub with a big cut surface. Wrap a thick pad of absorbent cotton wool or even old hessian or gunny cloth round the projecting stub to cover the cut surface completely. Soak the pad thoroughly with a 5% solution of common salt (about 28 grams. in 560 ml. water). Repeat the treatment after 4 or 5 days. This will kill the raghumala.

In very severe cases of attack the branch of the host plant may also die along with the parasite after this treatment in which case it should be promptly pruned away, the cut surface polished and painted with a protective paint such as Indopaste.

Chapter Seven

EPIPHYTES

EPIPHYTIC AND LICHENOUS FORMS OF RED RUST

Besides the parasitic one, two other forms of Red rust, occur on old tea leaves in shaded places. They produce the following symptoms.

1. Epiphytic form—Occurs as small, oval to circular spots, up to about $\frac{1}{6}$″ (4·2 mm.) in diam., lobed with an irregular margin, orange coloured and thinly covered with orange hairs (mostly sterile *i.e.* without sporangia at their ends), on the upper-surface only of hard, old leaves.

2. Lichenous form—Occurs as very small, more or less circular spots, about the size of a big pin-head, dull silvery-white to bluish-grey, thin and smooth, in large numbers on the uppersurface of old leaves only in heavily shaded places.

Control.

No treatment is necessary since both these forms are harmless.

LICHENS

In North-east India, the stems of tea bushes and shade trees are invariably marked with irregular patches of varying colours. Sometimes bunches of greenish-blue or ash-grey hairs and thin leaf-like growths of the same colour also hang on to the stems at intervals. The latter are thin, wrinkled, lobed and curled at the edges. These are all different forms of lichens which are the result of a symbiotic association between two plants *viz.* fungi and algae.

The most common form of lichen is the one which forms flat patches. These patches adhere to the bark so firmly that they look like irregular designs painted on with assorted colours *e.g.* dull-white, light to dark grey, bluish-grey, dark green—greenish-black, yellowish, brick red, etc. Some of the patches are plain, others are spotted with marks of various designs such as black globules or pointed black pin-heads (which are often confused with fructifications of Thorny blight—*Aglaospora* sp.), straight or curved, irregular, black, slightly raised lines, up to about $\frac{1}{8}$″ (3 mm.) long, small white or pinkish stars, dull-white, pinkish or black, irregular spots up to about $\frac{1}{4}$″ (6·3 mm.) across etc.

Lichens are not known to cause disease directly since they do not derive their nourishment from the host plant but their growth is more prolific on moribund plants and they may interfere to some extent with the normal expansion of the stems radially on hide-bound bushes by offering mechanical resistance.

Some lichens turn yellow or red at certain times of the year when the algal growth predominates; others turn vermilion-red when they come in contact with alkali such as caustic soda and lime.

The Red rust alga of tea grows in combination with a black fungus and forms small silvery, bluish-grey, more or less circular, lichenous spots on the upper surface of mature tea leaves in heavily shaded places. This form of Red rust is harmless (see page 48).

Control.

Healthy, vigorously growing plants require no treatment for lichens. Hide-bound tea bushes may be painted with advantage using a caustic wash (1—2%) or sprayed with a strong lime sulphur solution soon after pruning. 5% Ovicide is also known to remove lichens.

Hide-bound bushes should be nursed back to good health by judicious cultural operations.

MOSSES AND LIVERWORTS

In the Darjeeling hills as well as in moist, damp localities in the plains tea bushes often bear on the lower portion of the branches epiphytic growths of mosses and liverworts. These plants provide harbouring places for some insects otherwise they are harmless.

Besides tea mosses and liverworts may be found on most of the perennial plants growing in humid places.

Control.

They are easily rubbed off with a piece of sacking during the cold weather. Caustic wash (1—2%), strong lime-sulphur solution and 5% Ovicide are also effective in removing these superficial plants.

HORSE-HAIR BLIGHT—*Marasmius equicrinis* Mull.

This fungus sometimes grows on bits of dead stem and dead leaves which collect in the centre of the frame of tea bushes, especially in damp, shady places. It is also of common occurrence on the litter of dead leaves and twigs lying on the ground in bamboo baries. It is called Horse-hair blight because it grows in the form of black, shining threads or cords which closely resemble horse's hair. These cords attach themselves,

at random, to the fallen bits of stem and leaf and also to the dead outer tissues of the bark of living stems and thus form a tangled mass inside the bush.

The fungus is harmless since it never penetrates the live tissues of the host plant but it presents a very untidy sight.

Control.

Thorough cleaning out of the dead matter during pruning is all that is necessary to eradicate the fungus.

Rim blight or Marginal necrosis. Note chlorosis, curling and marginal injury of the tender leaves.

Chapter Eight

NON-PARASITIC DISEASES AND DAMAGE

RIM BLIGHT OR MARGINAL NECROSIS

(Plate 17)

Rim blight of tea is prevalent in varying degrees throughout the whole of North-east India.

It is a diseased condition produced, on the young leaves, not by the direct action of any parasitic micro-organism but by one or more of the following factors.

I. Damage by sucking insects such as Green fly (Jassid), Thrips and Pink mites.

II. Attack of *Poria hypobrunnea* or other wood destroying fungi lower down on the branches or on the main stem.

III. A period of hot, dry weather during or immediately after bud-break, on clean pruned tea, in poorly shaded or unshaded areas.

IV. Overdose of chemical manures, especially those containing nitrate of soda.

V. Application of chemical fertilisers to pruned tea before adequate leaf growth has taken place.

VI. Deficiency or excess of minerals.

VII. Chlorosis of the leaves, due to Red rust attack on the stems, or due to any other reason.

The disease always starts at the margin of the very young leaves. The serrations and the margin turn chocolate brown. This gradually extends inwards towards the mid-rib. The veins adjoining the affected area also turn chocolate brown on the under-surface and the green portion along the edge turns yellowish. As the green portions in the middle of the leaf continue to grow and expand in area the leaf curls, usually downwards. When only one edge is affected the leaf bends sideways. The affected area becomes thin and papery and it is often secondarily invaded by Brown blight. Grey blight, *Cladosporium* sp. etc.

Light leafed teas are more prone to Rim blight than the dark leafed ones.

Treatment.

(I) Tea affected by Jassid and Thrips should be sprayed on both the surfaces of the leaves with 50% water dispersible DDT using 1 lb. (·453 kilo.) of DDT in 40 gallons (181·84 litres) of water.

(II) Mite affected tea should be sprayed on both the surfaces of the leaves with 1 part of standard lime sulphur in 40—50 parts of water.

If Jassids and/or Thrips are accompanied by mites a combined spray of DDT and lime-sulphur, using 1 lb. (·453 kilo.) of DDT and 1 gallon (4·54 litres) of lime-sulphur in 40 gallons (181·84 litres) of water should be applied. This mixture deteriorates on standing.

(III) In drought susceptible areas, adjust the time of pruning so as to avoid budbreak during or immediately before a droughty period.

(IV) Do not apply any chemical manure until the new growth consists of, 2—3 fully opened leaves after top pruning and 3—4 such leaves after medium pruning.

(V) Where the predisposing cause is any of the wood destroying fungi mentioned above, treat the tea as the situation demands.

(VI) Establish adequate shade.

Bushes lightly affected by Rim blight often recover, towards the middle of the rains, without treatment.

SUN-SCORCH

Sun-scorch damage occurs not only on the thicker branches and the main stem of mature tea bushes in all the plains areas of North-east India but also on the leaves.

Sun-scorch on leaves of (1) **Mature bushes**—Sometimes during the rains almost all the fully opened, mature, exposed leaves in a section of tea suddenly turn chocolate red, within a few days as if swept by fire. This usually happens when a period of dull, wet weather is abruptly followed by one of hot scorching sunshine.

Affected leaves turn completely reddish-brown. Where a leaf is partially shaded, by another immediately above it, a sharp and clear impression is left on the leaf below, showing the shaded area quite green and the rest completely reddish-brown. The undersurface of the scorched leaves is usually coated in patches with a thin film of gummy, shining substance, as if lightly brushed with a varnish, which, is not quite dry. The young buds, immature leaves and the old leaves lower down are usually unaffected. The damage is invariably followed by Brown and Grey blights.

(2) **Young plants**—Young plants, planted out, in unshaded or poorly shaded new extensions, uprooted areas or as infills in old tea are sometimes affected by Sun-scorch when they are subjected to a period of strong sun immediately after transplanting. The leaves turn chocolate red, wither and exude a gummy substance on the undersurface.

(3) **Nursery seedlings**—On nursery beds when the shade is abruptly removed instead of thinning it out gradually or when it is suddenly blown down in a storm, the seedlings, especially those in the middle of the beds often lose their leaves due to Sunscorch. The leaves become yellowish-brown to reddish-brown, thin and papery and dry out.

Sun-scorch—Note formation of longitudinal wounds on the stem.

(4) **Pruned bushes**—In the pruning season, when bushes are cut across, the lower leaves being suddenly exposed to the sun get scorched. The leaves, in the centre of the frame, thus exposed develop slightly reddish-brown patches, between the lateral veins, starting near the mid-rib. Gradually these patches spread and join up to form a big patch extending over most of the central area of the leaf. By this time the damaged area is silvery-white above, greyish-white to brown on the undersurface and invaded by Brown and Grey blights.

When sun-scorched leaves are held against the light the affected areas, before they are invaded by secondary fungi, look semi-transparent, as if soaked in oil.

Treatment.

Establishment of adequate shade is the most effective precaution against Sun-scorch.

When mature tea is severely affected by Sun-scorch during the plucking season, the plucking table should be raised by leaving a leaf.

Young tea in uprooted areas and new extensions should be provided with temporary green-crop shade till permanent shade is established.

Sun-damage on nursery seedlings may be avoided by thinning out the shade gradually. This will help the leaves to adapt themselves to the increasing light and heat.

Scorching of old leaves following pruning is not serious.

SUN-SCORCH ON BRANCHES

(Plate 18)

Mature healthy bushes, especially those with vigorous growth, when medium pruned or heavy pruned before November, particularly after resting them for some weeks, are damaged by Sun-scorch, in varying degrees. It occurs practically in all the plains districts of North-east India.

When hot sunrays fall directly on the uppersurface of thick, horizontal branches and on the southern and south western surfaces of the vertical and oblique ones, the bark may be killed either in isolated, longitudinal patches or in one single patch extending throughout the whole length. Sometimes Sun-scorch occurs when a shower of rain is followed immediately by very hot sunshine, so that the bark is 'steamed off'.

Tea grown on stony ridges and southern aspects of hills sometimes gets Sun-scorch due to radiation from stones and terrace faces.

Some weeks afterwards, the bark cracks and peels off exposing the bare wood. On vigorously growing bushes, the exposed wood on smaller patches may be completely covered by callus growth, taking place from the edge of the affected area. On weak bushes, however, wound parasites such as *Poria hypobrunnea*, *Macrophoma theicola*, *Aglaospora* sp., *Nectria* spp., get in before the healing is complete. These fungi slowly work their way downwards, killing the living wood, until the main stem is reached when the bush is often killed completely.

Treatment.

Adequately shaded tea, when medium pruned at the proper time, rarely suffers from Sun-scorch. Medium pruned tea can be protected from Sun-scorch by intersowing the areas, in the early spring of the year of pruning, with *Tephrosia candida* or *Crotalaria anagyroides*. The green crop should be sown in alternate lines running North to South or North-west to South-east.

Painting of the branches, immediately following pruning, with a caustic wash mixed with lime will also reduce damage from Sun-scorch.

Piling up of the prunings on top of the bushes also reduces damage from Sun-scroch but this must not be done in hot dry areas where there is risk of fire. Where used, the prunings should be removed before bud-break takes place, in order to avoid damaging the new buds.

Exposed soil between the rows on stony ridges should be covered with a heavy mulch dressing.

LIGHTNING.

During the rainy season, lightning often causes sudden death of tea bushes in groups of anything from about 15 to 70 or more. More often a shade tree is included in the affected patch but somehow it escapes damage in most cases.

The leaves of the bushes suddenly wither, turn reddish-brown and remain attached to the branches for sometime, giving the impression of being scorched by fire. Bark and wood tissues of the above-ground portion, and to some distance below the soil level, are severely plasmolysed. When sliced with a knife the wood is seen to be discoloured evenly dark brown.

Treatment.

Bushes affected by lightning should be dug up immediately since they are likely to be rapidly attacked by Charcoal stump rot. The vacant area should be manured with a heavy dressing of well rotted organic manure, put under a green crop such as *Crotalaria anagyroides*, for at least a year and then replanted. If replanting is done without such treatment it is more likely to end in failure; sometimes even the grasses fail to grow in affected areas for a long time.

HAIL.

In the plains estates of North-east India local hail storms sometimes cause heavy damage to tea during the months of March—May. There are certain belts where hail storm occurs almost every year.

Cut-back tea and young tea suffer the most, especially when they are poorly shaded or unshaded and not protected by any green crop. In severe cases bushes may be almost completely defoliated and the branches badly barked on the uppersurface

or on the side from which the hail comes. Damage to the branches is comparatively less on top pruned and unpruned teas.

Hail cuts, if not protected in time, are liable to be infected by wound parasites such as *Nectria* sp., *Macrophoma theicola*, *Poria hypobrunnea* etc.

Treatment.

Where *Nectria* disease is known to be prevalent, tea barked by hail should be sprayed within 48 hours, with a 0·25% suspension of a suitable copper fungicide, preferably mixed with a spreader.

Where hail damage is of regular occurrence, establishment of a good shade canopy will reduce damage to a great extent. In the absence of permanent shade the tea should be protected by a green crop such as *Crotalaria anagyroides* or *Priotropis cytisoides*.

Where hail damage has been severe and much defoliation has been caused, manure with a quick acting fertiliser such as sulphate of ammonia but only when the tea puts on two or three new leaves following the damage.

DROUGHT

Certain tea growing areas in North-east India are subject to drought, not only in the cold weather but also often in the spring. Young tea plants and shallow-rooted mature bushes, in full leaf suffer the most. The intensity of damage varies according to the duration of the drought and other environmental conditions.

Affected plants, gradually wilt, the foliage at first develops discoloured patches in between the veins and then dries up turning reddish-brown. A thin varnish-like, shining, film is often noticed on the undersurface of the dried leaves. This condition is followed by die-back of the stems and finally the plants die out completely. The wood of the stems, which dry up due to drought, usually looks pinkish when sliced with a knife.

Tea in droughty areas is very susceptible to secondary diseases such as Red rust (*Cephaleuros parasiticus*), *Macrophoma theicola*, Brown blight, Grey blight etc.

Precautionary measures.

Drying out and baking of the surface soil should be prevented by heavy application of a mulch dressing.

Establishment of good shade is extremely essential in droughty areas. Shallow rooted shade such as *Albizzia falcata* (= *A. moluccana*) should be avoided.

Unpruned or skiffed tea suffers more from drought than pruned tea. In areas where drought is of regular occurrence the principle should be to prune into the drought and not so early as to allow the tea to enter into it with full new foliage.

Attention should be paid to good drainage.

The health and vigour of the tea should be maintained by adequate manuring at the proper time.

WATERLOGGING

In the plains of North-east India, tea bushes and some of the shade trees and green crops associated with them, often suffer from impeded aeration or waterlogging of the soil. This condition may be brought about by various factors such as flooding, low lie of the land, stiff clayey nature of the soil, high water table, an impervious layer of heavy clay subsoil, seepage water, saucer-like depressions around the collars of bushes due to the soil being cheeled away, puddling of the surface soil by cheeling in wet weather, total absence or improper drainage, and piling up of sub-soil around the collars while cleaning or deepening the drains.

The usual symptoms produced on the bushes are (1) the bushes turn sickly and yellowish, (2) plucking points are greatly reduced, (3) leaves are attacked by Brown and Grey blights and the stems by Red rust, (4) roots are shallow, twisted and bunchy with a tendency to grow upwards, ends often die back, surface becomes roughened due to enlargement of lenticels and ultimately they are attacked by Violet root rot.

Precautionary measures.

Improvement of drainage is the most essential thing.

Avoid cheeling during wet weather. Do not cheel away the soil from around the collar of the bushes without replacing it.

Do not pile up subsoil from the drains thickly near the drain-side bushes; carry it to the nearest path if possible or spread it out not more than an inch (2·5 cm.) thick in the tea.

Improve physical condition of the soil, where necessary, by occasional heavy dressings of green manure.

Do not attempt to grow shade or green crop species which are sensitive to impeded aeration of the soil.

HEAT DAMAGE

Tea bushes, especially the young ones and young shade tree plants growing on stony ridges, southern slopes of teelahs and exposed sandy soils which get baked in hot sun, are often damaged at the collar region by heat. The tissues of the main stem just near the soil surface are burnt on the southern and western side of bigger bushes and practically on all sides of smaller ones.

A ring of callus usually forms at the upper edge of the damaged lesion but smaller plants when completely girdled often die out in the same manner as from drought.

Sometimes young plants in the southern edge of nursery beds are damaged on the South-western aspect of their main stem in a longitudinal strip.

The leaves of severely affected plants wither, turn brown as in drought and curl inwards. The undersurface is sometimes thinly smeared in patches with a shining, varnish-like substance. Main stem at the collar region, when scraped with a knife, is found to be discoloured brown. Damaged lesions on the stem are usually affected by *Macrophoma theicola*, *Poria hypobrunnea*, *Diplodia* sp. etc.

Precautionary measures.

Heat injury of the abovementioned nature may be avoided by providing adequate shade or ground cover as the situation demands.

Damaged plants should be replaced.

MANURE INJURY.

Young tea plants in the field are sometimes seriously injured by wrongful application of chemical fertilisers, even when the amount applied is not too high.

Chemical manures, if applied in contact with the collar, especially during a dry period, absorb moisture from the plant tissues and cause plasmolysis. Also when rain following an application washes down the manure into depressions around the collar, thus bringing a concentrated solution in direct contact with the tissues, plasmolysis occurs. In the latter case the amount of manure, however, makes a difference; the higher the amount the greater is the risk of damage.

The symptoms produced on the plants are almost similar to those of severe drought or lightning. Plants may be found at different stages of wilting according to the intensity of damage. Severely affected ones die out completely. Some plants grow a ring of callus at the upper edge of the affected area which when scraped with a knife is seen to be heavily discoloured brown. The most characteristic feature of manure damage is that the discoloured area is found at the wilting stage to be sharply divided at the soil level, from the green tissues above. When the plants are dead for sometime this distinctive appearance is not so marked.

Precautionary measures.

Chemical manures should never be applied in direct contact with the collar of the plants.

It is always risky to apply chemical manures to plants situated in saucer-like depressions formed while cheeling.

Careful supervision is called for where children are employed in the application of manures.

Application of chemical fertilisers on to dry soil, following a prolonged dry period, is better avoided.

Dead and wilted plants should be replaced.

DEBILITY (OR LACK OF RESERVES)

Tea bushes, even vigorously growing ones, sometimes completely die out for no apparent reason, following a severe though necessary type of pruning such as medium pruning or decentering in case of young tea. It is also a matter of common occurrence, especially with older tea which is subject to adverse conditions, that bushes gradually deteriorate in health and ultimately die, without the intervention of parasitic diseases. There may be a few exceptions but these are only coincidences. Careful examination of such bushes shows that their death is caused by complete absence of reserves.

The tea bush, like all other green plants, manufactures the food necessary for its life and growth, in its green parts—mostly the leaves. Distribution of the elaborated food, to those parts where new growth takes place, is made from the leaves and the surplus food is transferred down to the roots to be stored up in the form of starch. The amount of stored reserve varies with the rate of growth depending on various factors such as climate, altitude, age, damage from pests and diseases, soil condition, cultural operations etc. When the green parts of the bush are completely removed by pruning or by some other agency, the carbohydrate reserve in the roots is mobilised for the production of new growth. No growth can take place in the total absence of reserves and the bushes die out.

A somewhat rough estimation of the amount of reserves in the roots may be made in the following way.

Select a number of representative bushes in an area. Dig up at least two healthy lateral roots, about the thickness of the little finger, from opposite sides of each bush. The end of the roots thus removed should be cut square across and smoothed with a sharp knife. Put a drop of iodine solution prepared either by (1) dissolving 1 gram of potassium iodide in 100 ml. water to which 0.3 gram iodine crystals are added or by (2) diluting hospital tincture of iodine to about 8 times with water.

The starch in the cells is stained black by the iodine. When the cut surface turns evenly deep black all over it may be considered full (100) while a root deplete of reserves will show no black colouration at all and it should be reckoned as 0. When the black colour covers less than 50% of the area the reserves are considered to be below par.

Vigorously growing young tea plants have a greater demand on the food manufactured in the leaves and as a result chances of their storing reserves are very small except during short periods of dormancy. Therefore, if complete removal of the food manufacturing area, by centering or pruning low, coincides with a vigorous growth period, when the roots contain no reserves, the plants cannot put on new growth and as a result they die out.

In medium pruned tea the bushes draw on their reserves for the production of new growth. Successful recovery after such pruning is relative to the amount of reserves stored up in their roots before the operation. If the reserve is inadequate the post pruning growth is thin and weak while in its total absence bushes fail to come away in the following growing season, branches die back and finally the bushes themselves die out completely.

The young leaves on a tea bush do not become fully efficient in manufacturing carbohydrates until they have attained maturity. In plucking bushes the growth of young shoots must therefore take place at the expense of food manufactured by the permanent mature leaves, below the plucking table. This maintenance leaf area is relative

to the height between the tipping and the pruning levels. Over plucking and plucking to too low a measure are two commoner reasons for lack of reserves. Bushes subjected to such conditions gradually become weaker and ultimately die out.

Similarly, prolonged attacks of pests and diseases, which, repeatedly destroy the maintenance leaf area, produce the same effect.

Measures to safeguard against depletion of reserves.

1. Principle of cultural operations should be to maintain good health of the bushes both young and old by preserving adequate maintenance leaf area, especially during the growing season.

2. Weak tea must not be medium pruned without resting for a minimum of 2 months prior to the operation, which, should preferably be carried out towards the end of a dormant (banji) period. Manuring with 30—40 lbs. (13·6—18·1 kilograms) N per acre (.404 hectare), before resting will be found to be beneficial.

3. Centering of young plants should be avoided during or immediately following a period of vigorous growth; it should be done towards the end of a dormant (banji) period.

4. Over-plucking and plucking to too low a measure should be avoided.

5. Pests and diseases, which, are likely to damage the leaf area, should be controlled by adopting suitable control measures at the right time.

6. Tea suffering from adverse climatic influences such as hail, drought and sun-scorch should be leniently treated.

RING BARKING.

In the not too distant past some estates used to ring-bark the main stem of young tea plants with the idea of inducing more shoot growth from below the barked ring. This is considered to be a dangerous process. It not only fails to produce the desired effect but often kills the plants by cutting off the transference of reserves to the roots entirely. The ringed area also provides a place of entry, very close to the roots, to wound parasites such as *Poria hypobrunnea*, *Macrophoma theicola*, *Aglaospora* sp., *Nectria* sp. etc.

Ring barking of old shade trees is recommended as a measure for depleting their reserves before felling so that the roots might be easily invaded and disintegrated by saprophytic fungi in the soil.

Caution.

Tea plants must on no account be ring-barked.

CALLUS GROWTH.

Callus growth is a natural process which takes place as a result of wound made on the living parts of a plant. It is an attempt on the part of the plant to repair the wound

by growing new cells from the adjoining uninjured tissues but in many cases the process goes much beyond the desired limit. Callus formation is then considered abnormal. Thus we occasionally see on the tea stems burrs up to 6 inches (15 cm.) or more in diameter with an irregularly undulated surface or hard, smooth, roundish galls up to about a foot (0·3 metre) in diameter while the stems themselves bearing these abnormal outgrowths may be only an inch or two (2.5 or 5·0 cm.) in diameter. Such growths are believed to be the result of some irritation caused on the stem by insects or other agencies in the past.

Filling up of small cuts and bruises on the stems or covering up of pruning cuts of healthy tea bushes with a reddish-brown growth which takes place from the edge of the damaged area is a desirable healing process.

Callus growth sometimes takes place also as a result of infection by parasites. *Macrophoma theicola*, *Hypoxylon asarcodes*, *Phomopsis* sp. and Red rust are instances of this nature. Such wounds rarely heal up, if at all, with the exception of Red rust, owing to the persistance of the organism deep inside the tissues.

Treatment.

Abnormal outgrowths should be removed as soon as convenient.

Healing of pruning cuts on thicker wood should be favoured by painting with Indopaste.

When callus growth is due to fungal parasites, treatment should be carried out according to the methods recommended under each individual disease.

DEFICIENCY DISEASES.

Growing plants require a balanced supply of mainly nitrogen, potash and phosphorus for their satisfactory growth. They also need a number of minerals such as iron, zinc, boron, manganese, sulphur, magnesium etc. in such minute quantities that they are termed as trace elements. Absence or nonavailability of some such trace element/s in the soil often causes certain diseased symptoms such as yellowing (chlorosis) of the foliage, marginal necrosis, curling, mottling, stunted growth etc., on many cultivated plants. Tea bushes in some other parts of the world have been reported to develop diseased symptoms in the absence of one or more of these important trace elements. Here in North-east India symptoms somewhat similar to deficiency diseases are produced on tea at certain times of the year either by climatic influences or by attacks of insects and microorganisms. These symptoms being transitory are not of much economic importance.

References.

On (1) Seedling diseases, (2) Diseases caused by parasites other than fungi, (3) Epiphytes and (4) Non-parasitic diseases and damage.

I.T.A. Memorandum No. 16—Notes on Stem Diseases of Tea in N.E. India, by A.C. Tunstall & K.C. Sarmah (1947).

I.T.A. T.E. Serial No. 36/3 under I.4.—Hail damage on tea estates by P.M. Glover, S.K. Dutta & K.C. Sarmah.

I.T.A. T.E. Serial No. 60/1 under I.4. —Drought, by P.M. Glover.

I.T.A. T.E. Serial No. 61/2 under I.4.—The prevention and cure of Red rust by K.C. Sarmah & P.M. Glover.

I.T.A. T.E. Serial No. 64/1 under I.3.—Violet root rot by K.C. Sarmah.

I.T.A. Serial No. 87 under I.4.—Lightning by K.C. Sarmah.

I.T.A. T.E. Serial No. 92 under I.2.—Key for identification of commoner diseases of young tea plants in nursery or field by K.C. Sarmah.

I.T.A. T.E. Serial No. 101 under I.3.—"Damping off" disease of young tea seedlings by K.C. Sarmah.

I.T.A. T.E. Serial No. 109 under I.4.—Rim blight or Marginal necrosis, by K.C. Sarmah.

I.T.A. T.E. Serial No. 119 under I.3—Control of diseases of Green crops by K.C. Sarmah.

Tea Pests and Diseases and their Control by E. Hainsworth, Heffer, Cambridge (1952).

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